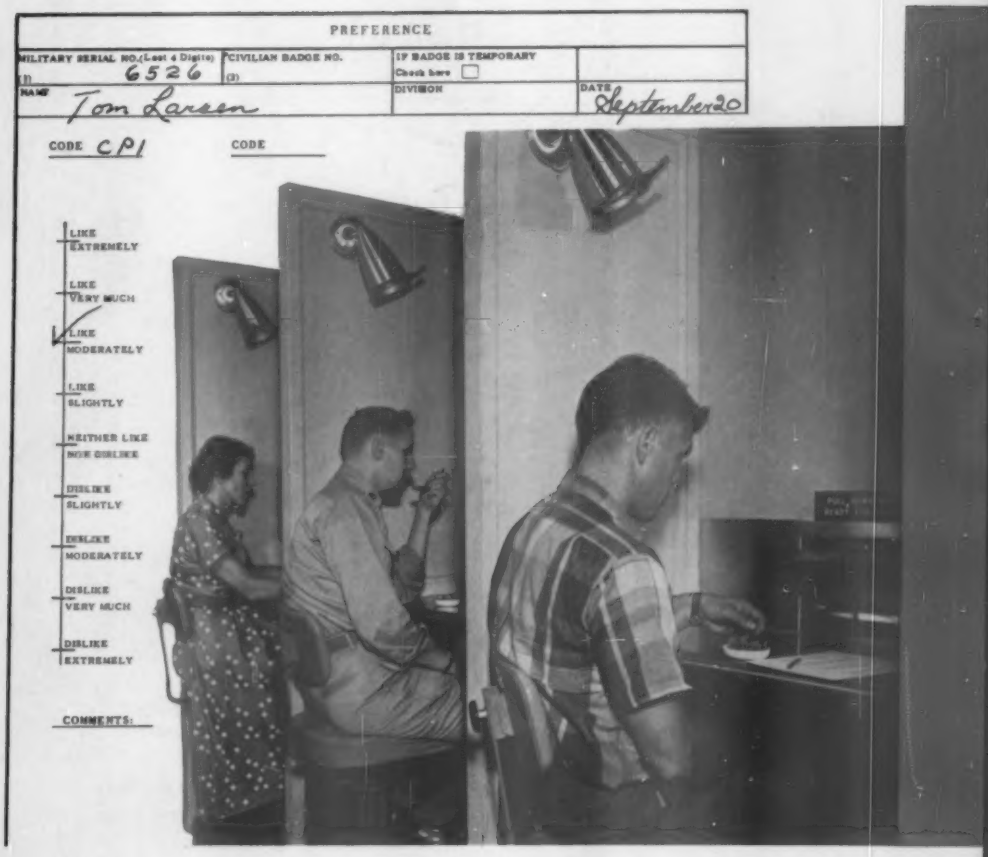
SEPTEMBER, 1957
Volume 11

FT food technology



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THE TECHNICAL ARTICLES IN BRIEF

Sensory Testing *Frozen Strawberries, Raspberries, Peaches*

Time-temperature tolerance of frozen foods. VIII. Organoleptic evaluation of frozen strawberries, raspberries and peaches. D. G. Guadagni.

A simple concept for the organoleptic evaluation of food products held at various temperatures is described. Procedure involves use of an objective-type difference test such as the triangle to compare samples held at an experimental temperatures against controls maintained at a temperature low enough to prevent deteriorative changes. Percentages of correct responses obtained in such a test are then plotted against time and the resulting curve provides information with regard to the rate and relative magnitude of the changes occurring at various temperatures. The curve obtained in this way also allows for comparison of results at any given probability level. Data are presented to show the effect of temperature and the reproducibility of the method over long periods of time. With commercial retail samples of frozen strawberries, raspberries, and peaches, it was found that 70 to 85% correct judgments gave more accurate and reproducible results than the percentage corresponding to a 5% level of significance.

Sensory Testing *Effect of Distraction*

Problems in taste difference testing. I. Test environment. John W. Mitchell.

Empirical evidence is offered on the effect of distraction on sensitivity in the taste difference test. Conditions included (a) one subject testing, (b) two or more subjects testing at one time, (c) one or more subjects testing, with noise or distraction occurring. A lowering of sensitivity is shown between condition (a) and condition (b). A drop in sensitivity is also shown between condition (b) and (c). The influence of psychological and physical environments on the sensitivity of the difference test is demonstrated.

Sensory Testing *Effect of Time of Test*

Problems in taste difference testing. II. Subject variability due to time of the day and the day of the week. John W. Mitchell.

The psychological and physical effect of time of testing on the sensitivity of the taste difference subject is shown. Data tend to support the theory that the subject does better during the earlier part of the week, poorer later in the week. As to the hour of the day, the data appear to indicate the middle of the day as optimal for testing. Both studies emphasize the fact that the various influences that may be affecting subjects during any particular test are important and should be considered in interpreting sensory test data.

Freeze-drying *Peaches*

Freeze-drying of fruit. S. Jackson, Suzanne L. Rickter and C. O. Chichester.

Peaches were torque-pitted, lye-peeled, and freeze-dried under vacuum. Four methods of heat transfer were investigated; single, double plate, infra-red, and dielectric heating. A Stokes freeze-drier was used for the first 3 heating methods. Heating plates controlled by auto-transformers were used for contact heating. Heat lamps whose output was controlled and measured were used for infra-red heating. Dielectric heating experiments were conducted in a glass vacuum chamber contained within a commercial dielectric heater. Drying rates were measured and compared for the 4 methods of heating.

Color and Consistency Evaluation *Peach Purée*

Objective evaluation of color and consistency in peach purée. D. E. Wilson, J. C. Moyer, W. B. Robinson and D. B. Hand.

Establishment of objective measurements of peach purée color and consistency is part of a study designed to improve the quality of purées made from eastern grown freestone peaches. These indices are being used to evaluate the effect of harvest maturity, post-harvest ripening, and processing variables on the quality of freestone peach purée.

This report deals with the preparation of experimental samples (representing a wide range of color and consistency), the selection of a panel of judges, and the conditions under which subjective and objective evaluations of color and consistency were conducted.

The interpretation of correlations relating multiple comparison test scores to Hunter Color and Color-Difference Meter, Bostwick Consistometer, and Brookfield Synchro Lectric Viscometer values is emphasized.

Package Materials *Beef*

Pigment changes in packaged beef during storage. Paul C. Pirko and John C. Ayres.

Reflectance spectrophotometry was used to measure spectra changes on surface of beef packaged in different materials. From minimal reflectance values observed, wavelengths characteristic for myoglobin, oxymyoglobin, and metmyoglobin were identified. After storage for 14 days in a refrigerated display case, pigment changes were confined to the wavelengths characteristic for these 3 pigments. At 635 mμ, packaging materials could be divided into 3 groups: (1) *Those wherein the concentration of metmyoglobin increased upon prolonged storage, reaching a maximum on the 6th day—300 MSAT 80-cellophane;*

THE SEPTEMBER COVER

One of the greatest developments in the food sciences in recent years has been the advance in sensory testing methods. Shown in the cover cut, courtesy of the Quartermaster Food and Container Institute for the Armed Forces, Chicago, is a modern taste test booth with one of the various types of scoring forms as background.

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Rating Quality and Intensity
Methodology of Flavor Profile
Consumer Acceptance Methodology
Simplified Uniform Procedure for Flavor Difference Evaluations
Collaborative Panel Testing

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Polyethylene 0.0015 in.; 80 FM 1-Pliofilm. Since reflectance values reached a minimum of 8-14% by the 6th day, the films were considered to be the least satisfactory of those tested. (2) *Those wherein maximum metmyoglobin formation occurred on the 4th day of storage—120 HM 1-Pliofilm; Polyethylene 0.0020 in.* With these films reflectance values were in the 13-18% range on the 4th day of storage. (3) *Those wherein maximum metmyoglobin formation occurred on the 1st day of storage—Aluminum foil 0.0015 in; FX 831; 450 K202-Saran coated cellophane; 517-Saran (gauge 50); Cryovac (evacuated and evacuated and shrunk).* Results showed there was least metmyoglobin formation with these packaging materials. Minimal reflectance values of 19-24% were obtained on the 1st day of storage and could not be detected thereafter. Also, regeneration of desired pigment formation of meats packaged in these materials was possible for periods as long as 14 days. In every case reformation of myoglobin was accompanied by decrease of metmyoglobin. Vacuum packaging of fresh meat did not result in greater discoloration than that taking place with other packaging films in this group.

Maximal values for metmyoglobin were observed to occur at the same time that minimal oxymyoglobin and myoglobin concentrations were obtained.

Desiccation of packaged meat was found to depend upon thickness of meat cuts, loss of weight being inversely proportional to sample thickness. Excessive loss of water resulted in surface hardening of the meat and a simultaneous increase in all reflectance values.

Reducing activity of the muscle tissues and gas permeability of the packaging material were important factors governing spectral changes.

FUTURE MEETINGS FOR FOOD TECHNOLOGISTS

September 8-13	One hundred and thirty-second National Meeting of the American Chemical Society, New York, New York
Sept. 17-24	Thirtieth International Congress of Industrial Chemists, Athens, Greece
September 30–October 2	Fall meeting of the American Oil Chemists' Society, Netherland-Hilton Hotel, Cincinnati, Ohio
October 9-11	Fourth Annual Symposium on High Vacuum Technology, Hotel Somerset, Boston, Mass.
October 14-16	Association of Official Agricultural Chemists, Shoreham Hotel, Washington, D. C.
November 18–December 9	Ninth Pacific Congress of the Pacific Science Association, Chulalongkorn University, Bangkok, Thailand
December 26-31	American Association for the Advancement of Science, Indianapolis, Indiana
April 7-11, '58	The American Association of Cereal Chemists, Netherland-Hilton Hotel, Cincinnati, Ohio
May 25-29	**Eighteenth Annual Meeting of the Institute of Food Technologists, Palmer House, Chicago, Illinois**

An open invitation is extended to readers of FOOD TECHNOLOGY to send in to the Editorial Office, 11606 South Bell Avenue, Chicago 43, Illinois notices of annual or national meetings of interest to food technologists.

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Industry and Education[a]

Additives Needed for Food Technologists[b]

Clarence K. Wiesman

Technical Director, Food Divisions,
Armour and Company

FOR THE TITLE OF THIS PAPER and much of the subject matter, I am indebted to a fellow committee member, Dr. Reed Milner. In suggesting this title he termed it "semi-wild," but I believe the title can be directly interpreted in terms which apply to familiar problems. *Additives* have made food more attractive and have improved our products. It is also safe to suggest that additives are needed to make our profession more attractive and to improve the quality of the people that enter it.

Clarence K. Wiesman

At the St. Louis meetings last year, Mr. R. E. Walters listed three main reasons why we can't find food technologists: 1) it is the fault of all of us in the food industry, 2) it is the fault of the home, and 3) it is the fault of the colleges and their curriculums. Through our efforts all of these faults can be corrected to a greater or lesser degree.

Essentially, we have the problem of advertising our profession and the training necessary to enter it. The question is: How do we approach this problem in terms of *Public Relations?* Ideally, we would like to reach people in all walks of life—tell them our story and let *them* do the selling job. However, we realize that our efforts and particularly our initial efforts must be directed towards a more limited audience. We should seriously enlist science teachers on the primary and secondary level, students—perhaps at the sophomore level in high school and up, and all parents. I say *all* parents because parents start thinking of a desirable profession for their offspring at about the crib stage. They may not be serious in such considerations, but it wouldn't hurt if they knew that such a profession as ours exists—and offers real opportunities and prestige.

I might add that I do not believe I am exceeding the bounds by including science teachers at the grammar school level. If you get a chance, look through a 7th and 8th grade science text. If you have not done this, you are in for a big surprise. Fats, carbohydrates, proteins, metabolism, amino acids, endocrine glands, and even chemical elements are terms *familiar to junior high kids.*

GETTING DOWN TO METHODS

Now, let us get down to specific methods and procedures. The most familiar area to all of us is our own companies. At present, we often hire a bacteriologist, chemist, biologist or engineer and set about making a food technologist out of him. Perhaps we can improve our method of doing this. We can encourage further academic training through permitting time off for attending classes, through full or partial payment of tuition, and, of course, salary increases. We can foster short courses, lecture courses, symposia, fellowships or scholarships (not only for employees but also for children of employees) as a means of acquainting desirable students with our profession, encouraging them to enter it, and holding them after they are in it.

Most of our companies provide for fellowships and consultantships in our research budgets. It might not be a bad idea to provide industry money for boosting teachers' pay. Certainly such a gesture would make teachers more sympathetic to our problems.

In our recruiting, we can emphasize the facilities we have, the high caliber of our research programs, the fringe benefits, and the encouragement we give our people to publish research, present papers, and participate in professional organizations such as the Institute of Food Technologists.

At Armour our recruiting program includes a sum in the budget for summer employees—high school seniors and college people. I wish we could do more of this kind of recruiting. It has attracted some mighty good people to the food field.

WHAT ABOUT MANAGEMENT'S ROLE?

Now what about our management? Unlike the chemical and electronic fields, the top management of the food companies are not generally technical people. Nevertheless, cooperation of our top executives is necessary. Although management may be aware of the need for food research, they seldom think of it as an aid to publicity or advertising.

All of our companies use the press, radio and television. The chemical industry—as for example, Dupont—has "sloganized" research. If you watch "Cavalcade" on T.V., you know what I mean. The

---

[a] Moderated by Dr. W. A. Maclinn, this session of the Seventeenth Annual Meeting of IFT at Pittsburgh consisted of presentations by five speakers and was followed by a general discussion. Other papers will appear in subsequent issues of *Food Technology.*

[b] Presented at the Seventeenth Annual Meeting of the Institute of Food Technologists, Pittsburgh, Pennsylvania, May 14, 1957.

food industry in its advertising extols quality, customer service, variety, and many other attributes which are often the results of Food Technology, without ever mentioning the important part that research and development plays in the success of a product. Well, let us get some slogans and get our management to use them in their advertising. For example—"Today's Research Sets Tomorrow's Table." And some night, in place of the regular commercial, we could have a talk (or short film) on "Food Research in Your Market Basket."

Our management should promote open house tours. Prior to World War II thousands of people were conducted on plant tours through the packing plants of the Union Stock Yards in Chicago. Although these tours were interesting and informative, they were also misleading. Many facets of the packing business were not even mentioned—leather, refinery, dairy and poultry operations, to mention a few.

Of all these thousands of visitors, very few ever realized that hundreds of scientific personnel were at work in these same stock yards representing many phases of scientific endeavor, recruited from our finest academic institutions.

I have wondered if other food industries are in a similar fix.

Do we show bright, clean manufacturing areas but never the laboratories in which Food Technologists are at work?

Exhibits of various kinds are always popular and in this respect we can let our imaginations run wild. Many of us prepare exhibits for our companies which tell the Food Technology story. Portable exhibits are always in demand at conventions, high schools, colleges, and even in public institutions. In the exhibit of the fixed type I can think of none finer than the one which Swift and Company maintains at the Museum of Science and Industry in Chicago. It is suggested that the research personnel of Swift arrange for part of this exhibit to show how the Food Technologist fits into the picture. And, finally, as company employees let us get out and talk to P.T.A. groups, to service organizations, and the like.

WHAT CAN IFT DO?

Up to now I have stressed what we, as individuals, can do. Let us see what the Institute of Food Technologists can do collectively.

Mr. Walters indicated that we must get into the homes of the high school graduate and approach both the students and the parents. Here the high school principal, science teachers and student counselors are valuable allies. I believe that an IFT Speakers' Bureau, restricted to high school audiences, would be very effective. In a section like Chicago such a program could be extremely flexible—not only could we cover all phases of the food industry, but the talks could be *as general* or *as specific* as the occasion demanded. Films are a valuable aid to such an activity. However, film "strips" are not only cheaper, but lend themselves better to a formal presentation.

This same bureau could offer assistance to guidance programs in high schools. (Here is a good area of participation for Phi Tau Sigma.) In this area, many of us would like to have IFT scholarships available to high school seniors. One or two scholarships in each section could promote our goals better than any other single activity of the IFT.

An example of the potential of the regional section was brought to my attention by Dr. Milner several months ago. In January, the Indianapolis Section had a *career* day for high school students in Rice Auditorium at Indiana University. The program included top men in industry and academic institutions. Colored films were shown. Students visited the laboratories and were furnished literature describing careers in Food Technology.

The success of this venture is amply substantiated by the 3-page article which appeared in the Sunday magazine section of the Indianapolis *Star*.

The Indianapolis Section is to be commended for this bold and outstanding venture—one that should give all of us considerable encouragement and many ideas on how to present our profession to the public. The extracurricular activities of our teen-agers present a wide-open area for public relations and career salesmanship—4H clubs, scouting groups, high school science clubs, and state academy of sciences are just a few that come to mind.

I have already touched on the field of press, radio, and television, but for a specific IFT activity we should enlist the cooperation of local T.V. networks. Cooking programs are a classic example. IFT could participate as guests or even provide suitable commercials and/or part of one or more programs. Our daily newspapers provide an open door through the homemaker's page. Our journals, such as the *Prairie Farmer*, would no doubt permit us to tell our story to our basic suppliers of raw materials.

A second area where we can reach the parents is the public show. For example, nearly 400,000 people attended the National Livestock Show in Chicago last December. The exhibits on meat were excellent and attracted considerable attention. At the time, I wished that the Institute of Food Technologists could have had a similar exhibit there. State and county fairs, department store displays, museums—these are yet other examples of places that have mass attraction.

The publicity job I have just outlined for press, radio, and television is certainly a tremendous undertaking—a great deal more than any one of us would attempt to do. It must be a vigorous group effort.

Equally important, it requires someone skilled in publicity and promotion, someone who has the skills of interesting the public in what he has to sell. We should have a full-time publicity man on our national office staff—someone who can work with us and provide an organized program to interest the public in our field in the years ahead.

Finally, let us not go it all alone. There are many organizations and institutions which are potential partners in this activity. Joint ventures with trade and other professional organizations such as

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the American Meat Institute, the National Livestock and Meat Board, the National Dairy Association, the American Chemical Society, and the National Association of Manufacturers are desirable allies and should be enlisted. We can profit much from their experiences and gain some of our objectives at the same time.

I realize I have covered a great deal of territory in what I have said—also that there is much more that could be said. My chief purpose has been to suggest ways and means of establishing Food Technology in the minds of the public as a profitable and interesting occupation carrying with it an opportunity for self-satisfaction and prestige.

NOW IS THE TIME

Food Technology as a profession is really in its infancy. Now is the time to start a program designed to build up its professional status to the level which it deserves.

The IFT is deeply concerned with the problem of presenting food technology as a career. A committee on education has been set up with Dr. Maclinn as chairman. There are two sub-committees: one on accreditation, the other on professional status.

The professional status committee on whose behalf I am speaking today feels that the primary objective is one of getting people interested in Food Technology and attracting desirable students into the food field. The problem of status is one that can be undertaken after the primary program is under way. The recommendations of the sub-committee on professional status this year are along the lines discussed in this paper.

To summarize, we have recommended that the problem should be approached in three ways:

1. Through Regional IFT Sections, by means of Speakers' Bureaus and Career Conferences.
2. At the national IFT level, by sponsoring scholarships, hiring a commercial public relations firm, and by supplying assistance to regional sections in their promotional activities.
3. Through Industry, by encouraging company scholarships and educating management to play up Food Technology in their advertising and promotional programs.

The Food Technologist in 1957 — Salary and Professional Picture

Roy E. Morse

Professor of Food Technology, Rutgers University, New Brunswick, N. J.

As THE PROGRAM INDICATES, this was to have been a report of the survey conducted by the Institute of Food Technologists of the Professional Status of Food Technologists at this moment. During the Council Meeting this year, on recommendation of the Executive Committee it was decided to defer this study until a later time. It is hoped that this project will not die. There is a great deal to be gained for the individual members from a study of this kind. Members have already made use of the survey extracted from the literature last year. Concise, concrete evidence will not be available until this survey is done.

Roy E. Morse

With the knowledge that this survey would not be conducted, a much briefer survey was conducted by the author with the hope that data of use could be derived. Accordingly, a salary questionnaire was sent to all Universities conducting courses in Food Technology and with eternal thanks it should be noted that *all* replied—a phenomenal response and indicative of the interest in this subject at the University level.

The results of this survey are presented below, with the note of caution that not all positions in the food industry are filled by Food Technology graduates and the graduates of the various schools are not necessarily placed in their own area. Keep this in mind when interpreting the data below.

SOME FACTS AND FIGURES

Table 1 shows the total Food Technology graduates in 1956 with geographical distribution. The arbitrary geographical distribution is that of the author. There was a grand total of 171 graduates. At the B.S. level there was quite uniform nationwide distribution; 26% in East, 22% in the Midwest, 32% in the Far West and 20% in the South. The M.S. level shows a slight bulge in the Midwest, 37%, the East, 25%, the Far West, 28% and in the South, 10%. The Ph.D.

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TABLE 1

Total food technology graduates—1956

	B.S.	M.S.	Ph.D.
East	24(26%)	11(25%)	16(43%)
Midwest	20(22%)	16(37%)	16(43%)
Far West	29(32%)	12(28%)	5(14%)
South	18(20%)	4(10%)	0
Total	91(53%)	43(25%)	37(22%)
Grand Total	171		

level showed equal distribution in the East and Midwest, 43%, with 14% in the Far West, and none in the South.

Table 2 shows the breakdown by schools of the various graduates. Oregon State graduated the most B.S.'s—19; California produced the most M.S.'s—10; and the most Ph.D. graduates came equally from MIT and Illinois—namely, 7.

TABLE 2

Food technology graduates—1956

	B.S.	M.S.	Ph.D.
East			
MIT	8	1	7
Rutgers	2	2	4
Massachusetts	11	8	4
Maryland	3	0	1
Midwest			
Iowa	0	4	2
Michigan State	5	1	0
Ohio	3	1	3
Purdue	0	2	2
Illinois	5	6	7
Wisconsin	7	2	2
Far West			
Oregon State	19	2	2
California	10	10	5
South			
Miami	3	0	0
Georgia	12	3	0
Virginia P. I.	3	1	0

Table 3 shows the weighted starting salaries by area in 1956. The high is $8,350 for an Eastern Ph.D., and the low is $4,335 for a starting Midwestern B.S. Those with an M.S. obtained about $1,000 over the starting B.S., and those with the Ph.D. obtained from $500 to $3,000 over the M.S. More about this later.

TABLE 3

Food technology starting salaries—weighted averages
1956

	B.S.	M.S.	Ph.D.
East	$5,050	$6,000	$8,350
Midwest	4,335	5,300	6,850
Far West	4,850	6,350	7,080
South	5,050	5,800	.....

The next table, Table 4, is the starting salary for chemists in 1956. This is given for purposes of comparison with the data on food technologists. It may be seen that both sets of starting salaries compare favorably.

TABLE 4

Chemists—starting salaries—1956[1]

	B.S.	M.S.	Ph.D.
	per month		
Chemists	$400	$443	$600
Chemical Engineers	$432	$485	$604

[1] *Chemical and Engineering News* is the source.

THE CURRENT OUTLOOK

Respondents to the questionnaire were asked to comment on the number of available positions compared with the number of graduates. Some comments were extracted and are given below.

"Three to five times as many jobs as applicants"—Univ. of California.

"About half the graduating bachelors of science go into the army"—Univ. of Georgia.

"Three jobs per Ph.D. graduate"—Ohio State.

"Demand overwhelming, supply inadequate"—Iowa.

"More jobs than people"—Purdue.

"Many go on for a graduate degree"—Virginia Polytechnic Institute.

"Many more requests than we can hope to fill"—Massachusetts Institute of Technology.

Other comments:

"B.S. salary in 1957 up $200 over 1956"—Univ. of Georgia.

"Ph.D. salaries in 1957 higher than in 1956 although still below those offered chemists"—Univ. of Illinois.

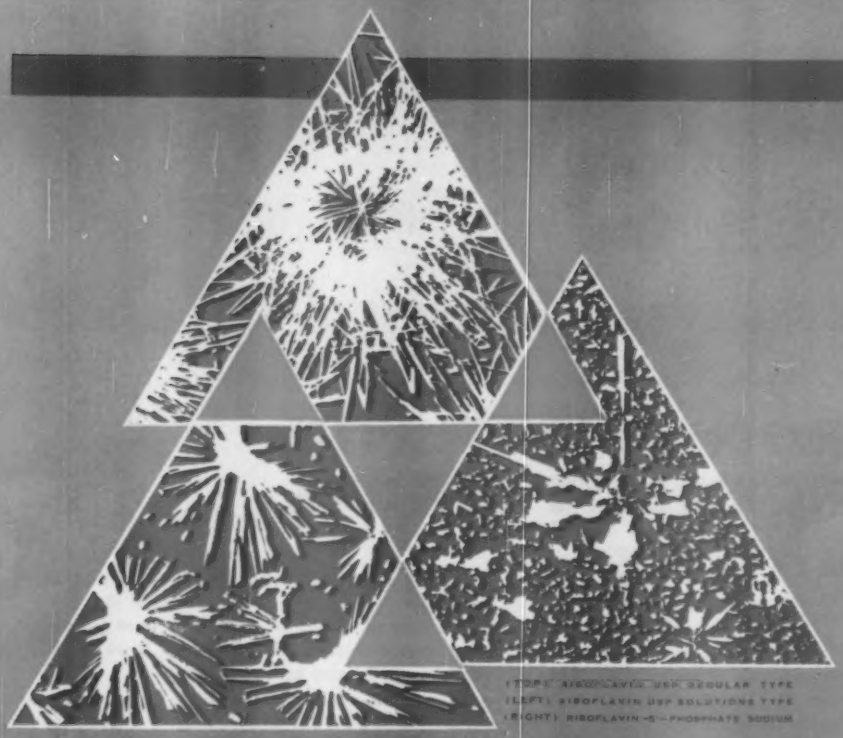
"No benefit of M.S. over B.S. except as experience"—Purdue.

"Salaries vary, depending on industry"—Purdue.

"Food technology graduates seem to start just under engineering graduates."—Univ. of Massachusetts.

"Ph.D. salaries vary, depending upon individual"—Massachusetts Institute of Technology.

"Starting salaries are up for B.S. and M.S. over 1956, more for Ph.D."—prominent industrial employer of food technologists.



(TOP) RIBOFLAVIN USP REGULAR TYPE
(LEFT) RIBOFLAVIN USP SOLUTIONS TYPE
(RIGHT) RIBOFLAVIN-5'-PHOSPHATE SODIUM

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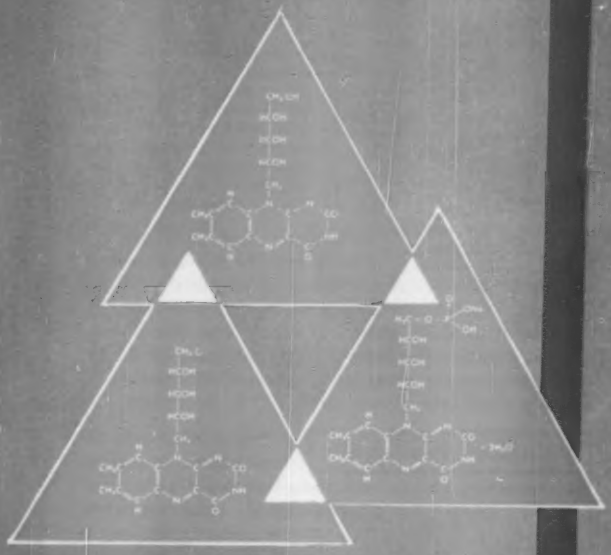

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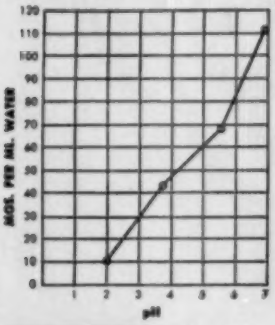

SOLUBILITY of Roche riboflavin-5′-phosphate sodium in water at different pH levels; room temperature.

These data show that solubility of Roche B_2 phosphate sodium depends on hydrogen ion concentration in water. It is useful to note that the solubility of riboflavin U.S.P. (approximately 0.12 mg. per ml.) inserted on graph would fall just above the base line.

specifications

Tests show that B_2-5′ (M.W. 514.4) has the full theoretical activity on the molecular basis of riboflavin (M.W. 376.36). Theoretically one gram of the phosphate is equivalent to 0.73 grams of riboflavin. The Roche product contains small amounts of moisture, disodium salt, diphosphate ester and unesterified riboflavin. It has a riboflavin activity of 70-73% by weight.

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Roche riboflavin-5′-phosphate sodium has immediate biological activity because it is identical with the natural flavin mononucleotide occurring in the "yellow" respiratory tissue enzyme system.

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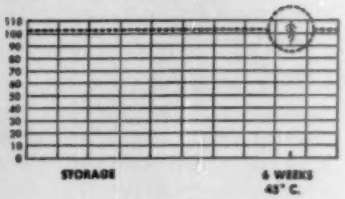
Even though the cost of Roche B_2-5′ is somewhat higher than regular riboflavin, its use can result in actual savings. You eliminate expensive solubilizers and unnecessarily large amounts of niacinamide. You reduce or eliminate costly complaints and returns. You are able to make manufacturing economies.

stability

Chart demonstrates stability of Roche product in B-complex parenteral solutions with and without vitamin C over wide potency range.



uses

The new riboflavin-5′-phosphate sodium, probably the most important riboflavin development since Roche introduced the vitamin commercially in 1941, is specially designed for use in manufacturing:

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Of Professional Interest

Panel Discussion on Chemicals in Foods

Moderator, Dr. F. N. Peters, Jr.

Developments in the technological application of chemical additives in food processing were reported at the Seventeenth Annual Meeting of the Institute of Food Technologists in Pittsburgh last May. Presented herewith are condensed versions of the remarks of three panelists.

Status of Food Additives Legislation, as of July 10, 1957*

Frank L. Gunderson
Washington, D. C.

NOTE! CONGRESSIONAL COMMITTEE HEARINGS on Food Additives will start on July 15th!

There are, in early July, nine legislative Bills in the House of Representatives and one in the Senate concerning food additives. Also, there are two House Resolutions for the establishment of a Select Committee to investigate and study the subject. The list of legislation introduced in The 85th Congress which convened in January 1957, follows:

Rep. O'Hara, H.R. 366, introduced January 3.

Rep. Delaney, H.R. 4014, January 29.

Rep. Sullivan, H.R. 4432, February 5 (identical with H.R. 4014).

Rep. Burdick, House Resolution 212, March 25 (proposes a Select Committee to investigate Food Additives somewhat as was done by Rep. Delaney's Sel. Com. several years ago).

Rep. Harris, H.R 6747, April 16 (the "Administration" or FDA Bill).

Sen. Hill, S. 1895, April 16 (identical with H.R. 6747).

Rep. Fulton, H.R. 7700, May 22 (identical with H.R. 4014).

Rep. Delaney, H.R. 7798, May 28 (supersedes H.R. 4014).

Rep. Teller, House Resolution 273, June 5 (somewhat similar to House Resolution 212).

Rep. Sullivan, H.R. 7938, June 5 (identical with H.R. 7798).

Rep. A. L. Miller, H.R. 8112, June 13.

Rep. Harris, H.R. 8390, June 26.

Rep. John B. Williams of Mississippi, Chairman of the Health and Science Subcommittee of the House Interstate and Foreign Commerce Committee, announced during June that Hearings on the Bills will be held in the latter half of July with exact starting date to be announced later, now set for July 15.

Hearings on the Natural Gas Bill and other duties have prevented the Committee getting to the food additives subject earlier. It is quite unlikely that this subject will be advanced far enough during the First Session of The 85th Congress to permit final action this year.

Rep. Burdick's House Resolution 212 and Rep. Teller's identical Resolution 273 are not legislative "Bills"; rather they would set up a Select Committee to conduct an investigation and study along the line of those held by the Delaney Select Committee several years ago.

All proposed legislation provides for mandatory pretesting and for mandatory submission of data on the safety of the proposed additive to the FDA before the marketing of a food with a new additive. In other respects there are many variables. Several Bills provide for an ad hoc Scientific Advisory Committee of research experts to be designated by the National Academy of Sciences—National Research Council. The judicial procedure in case of disagreement on the interpretation of scientific evidence, a most controversial point, varies considerably between the extremes of H.R. 366 and H.R. 6747. In other respects the variations are too numerous to describe in this brief report.

Rep. Williams' office made public announcement in June that he has invited Dr. Detlov Bronk, President of N.A.S.-N.R.C., to name a list of experts who will be heard on the scientific aspects during the official public Hearings.

Copies of House Bills are ordinarily available on written request, by number, to the House Document Room, and for Senate Bills to the Senate Document Room, each in the U. S. Capitol, Washington 25, D.C.

One can be listed to receive notice of forthcoming Hearings on Food Additives by request to the Subcommittee on Health and Science of the House Interstate and Foreign Commerce Committee, Room 1334, New House Office Building, Washington 25, D.C.

To the writer of this section it appears that considerable harm is done the food industries and those

* This panel discussion, sponsored by the IFT Committee on Chemicals in Food, was held May 15 at the Penn-Sheraton Hotel, Pittsburgh, Pennsylvania.

motivated by constructive educational intentions on food additives the longer legislation is delayed. Although there is no positive necessity for legislation on food additives, the subject is widely publicized, the pressures for legislation are quite strong, and it is expected that an Amendment will eventually be enacted.

The simplest kind of legislation would contain only two features; namely, making mandatory the pretesting which is now done on a voluntary basis, and making mandatory also that the data be submitted to the FDA in advance of marketing the food with the new additive. All other features of the proposed legislation are controversial. Alarmists would have consumers believe that various new additives are being marketed without benefit of pretesting for safety. That is far from the truth, for voluntary pretesting and presentation of data to FDA are customary. If we accept that additional legislation on food additives is inevitable then there could be some constructive benefits by early enactment of a practicable amendment. Purely as a guess, it now appears in July 1957 that with Hearings in this 1st Session, Food Additive legislation will not be enacted earlier than 1958, during the 2nd Session of this, The 85th Congress.

"Let Us Raise a Standard to Which the Wise and Honest May Repair"

F. N. Peters, Jr.

The Quaker Oats Co., Research Laboratories, Chicago, Illinois

IT WAS LESS THAN SIX YEARS AGO that an article appeared in a well-known nationally distributed magazine entitled, "Peril on Your Food Shelf." The introduction to that article read as follows:

> "In this article, the head of a Congressional committee reveals evidence that hundreds of untested and unproved chemicals, in the hands of irresponsible food manufacturers, are threatening the health and even the lives of our families."

Other articles of similar nature appeared under the titles, "Are We Eating Poisoned Foods?" and "Bread—The Phony Staff of Life"; and in the August 1, 1951 report by the Senate Committee on Forestry and Agriculture, this statement appeared:

> ". . . many of the flours contain phosphorus, fluorine, silicon, alum, nicotinic acid, potassium bromate and a score of other poisonous drugs."

Amendments to the Federal Food, Drug and Cosmetic Act were being sponsored at that time just as they are today, but the composition of those amendments differed in many important respects from the bills just discussed by Dr. Gunderson. Indeed, some of them were so drastic that certain members of the food industry were concerned that, should these proposals be enacted into legislation, incalculable harm would be done to the food industry. It would lead to loss of incentive for research, would make it very difficult to develop new foods, and certainly would curtail and delay the adoption of new technological processes. Anything the food manufacturer said in his own behalf was viewed with suspicion by legislators and news reporters. On the other hand, many statements by Food and Drug Officials were considered unfair or misleading by members of the food industry.

It was in this atmosphere of suspicion and mistrust that a small group of representatives from the food and chemical industries proposed to the National Research Council that a committee be formed consisting of experts competent to advise on matters of food and its relation to public health. It was as a result of this recommendation that the Food Protection Committee was established as a sub-committee of the Food and Nutrition Board. It held its first meeting in September 1950.

It is a fact-finding and advisory body for both government and industry. It is an independent organization, solely responsible for its own conclusions and decisions. Members serve without pay, but the cost of travel, publications, and support of an Executive Secretary is derived from contributions from food, packaging and chemical industries, commercial laboratories, and a few individuals. These contributors become members of the Liaison Panel and each year, usually in December, meet with the Food Protection Committee to discuss reports made during the preceding year, consider problems currently being studied by the Committee, and to suggest areas where more knowledge seems desirable. At this same meeting, the industrial members of the Liaison Panel elect an Industry Committee which raises funds for the program, advises the Committee in respect to problems

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where industrial assistance or guidance is needed. Most important of all, however, is the fact that the Food Protection Committee gives the Industry Committee copies of preliminary drafts of articles before they are finally drafted for publication. If the Industry Committee has any objection, criticism, or suggested additions, its views are considered carefully by the Food Protection Committee before a final draft is made. Let me make it abundantly clear—the Industry Committee exercises no power of veto—it has only the privilege of presenting the industry viewpoint and having assurance that such will be given through consideration. I can say from personal experience, and I am sure that Doctors Spencer, Gunderson and Clifcorn of this Committee will agree, the industrial viewpoint receives most careful consideration and each problem presented by industry to the Food Protection Committee is given a great deal of thought and more often than not is included in the FPC program.

The Food Protection Committee also receives requests for aid from the Food and Drug Administration and other governmental organizations. It is an agency that has no axe to grind; its function is to determine facts. It deals with current and practical problems for which industry and governmental agencies need answers. Sometimes final answers cannot be given, but the problem can be defined and the controversial points brought into focus and the area of needed experimental work may be indicated.

spice RESEARCH NEWS

New Test for Judging Quality in Natural Black Pepper

A new, modified colorimetric procedure for determining quality in pure, natural black pepper has been developed. Based on the piperine content of the spice, the new test provides a more accurate, simpler and faster way of gauging the quantity of piperine present than previous techniques. Piperine, the substance associated with pungency and bite strength in pepper, is measured by color developed with special reagents. This test, coupled with a recently developed method of analyzing volatile oil, the aromatic factor in black pepper, makes it possible to measure more accurately the flavor of the spice.

This is one of many new developments in the spice trade's current program of research on natural spices. New facts are steadily making it more apparent that the pure, natural spices offer the modern food manufacturer flavor performance not obtainable from any other flavoring materials.

* * * *

MORE DETAILS . . . on the new Piperine Test for Natural Black Pepper are available from the Information Bureau American Spice Trade Association, 350 Fifth Avenue, New York 1, N. Y.

American Spice Trade Association

The Committee's first publication was "Use of Chemical Additives in Food," issued in December 1951. Let me quote from this, and I ask you to remember that these statements were published shortly after the appearance of the alarmist articles mentioned a few minutes ago.

> "Foods are themselves composed of chemicals, such as carbohydrates, fats and proteins, Chemical additives are employed to improve nutritional value, enhance quality or consumer acceptability, preserve food, or to make it more readily available. . . . There need be no hazard in the use of chemical additives, provided adequate scientific research programs are carried out prior to use. The fact that a chemical is toxic does not mean, *per se*, that its proper use as an additive will entail a hazard."

Subsequent publications have dealt with the safety of such additives as mono- and diglycerides, polyoxyethylene stearates, artificial sweeteners, and surface active agents. Year after year the charge is repeated that "hundreds," sometimes it is "several thousand" untested chemicals are used in foodstuffs. No one really knew how many there were, what they were, or how much was used. Who can answer these questions? The problem was discussed with the Food Protection Committee and assigned to its Food Technology Subcommittee. With the cooperation of many industrial concerns, trade associations, the Liaison Panel, and Industry Committee, material was collected and eventually published in 1956 as "The Use of Chemical Additives in Food Processing." In this book is listed every chemical for which the Committee found authentic evidence of use. With continued industry cooperation, this book can be revised and made even more authoritative. Let me read excerpts from the introduction:

> "The widely publicized Delaney Committee statement has caused apprehension as to the safety of processed foods. Considerable stimulus has been given to the adoption of food practices that are without economic or scientific justification. Evidence of this can be found in the efforts of consumers to obtain, for example, oranges grown without chemical fertilizer, raisin grapes grown without insecticides, or bread made from unbleached flour.
>
> "The mere statement that a definite, large number of chemicals is used in foods is uninformative or even misleading. It is necessary to know what the chemicals are, the extent to which they are used, and the foods to which they are added. Many of the estimated 704 chemicals are used in such minute amounts and in such infrequently consumed foods that negligible quantities are involved. Some, such as salt, baking soda, vinegar, and vegetable colors, are used in every kitchen. Others are used in such manner that they disappear completely from the food before it is consumed. These are called transient chemicals."

Last fall, many newspapers and magazines carried stories arising from an international conference of

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cancer experts held in Rome. These stories gave the general impression that carcinogens are being added deliberately to American food. Such statements lead to a clamor for laws prohibiting additives of any kind, and to a loss of public confidence in the integrity of the food industry. At the request of the Industry Committee, the Food Protection Committee in December 1956 issued a statement on the subject. It was given to many journals and the wire services. The statement was not sensational—scientific reports seldom are—but it was factual and reassuring to anyone willing to take the time to study it. It is the best rebuttal the food industry has today to the charge we are deliberately adding carcinogens to foods.

The Food Protection Committee has had an ad hoc committee on dietary carcinogens for the past two years. In 1957, a subcommittee on carcinogenesis has been recommended and undoubtedly will be active during the remainder of this year. Plans for additional conferences on this subject are already formulated.

Subcommittees on food technology, pesticides, and toxicology will continue working in their fields. Among current problems of particular interest to the Institute of Food Technologists is one dealing with packaging materials. There is an ever increasing variety of packaging materials available to the food manufacturer. Since many of the films and adhesives are synthetics which come into contact with foodstuffs, it is only prudent that we know such materials as are used do not create health hazards.

As industry has new problems that could affect public health and brings them to the FPC, and as we give more and more support to this Committee, a better understanding of the entire field will develop and all of us will be the gainers. I believe George Washington is credited with the statement that goes somewhat as follows:

"Let us raise a standard to which the wise and honest may repair."

I believe in the field of food additives, as it may affect public health, the Food Protection Committee is such a standard and thus deserves widespread support by the food industry.

Reference was made a little while ago to alarmist statements arising from the Delaney Committee in 1950 and to similar stories coming from the Cancer Conference in 1956. I believe you may be interested in a few additional statements that have appeared in the past 6 or 8 months. (The articles shown on the first seven slides were from publications having a combined monthly circulation of about 600,000. The next two slides illustrated types of authoritative rebuttal to the scandal mongers.) These are illustrations of material published by Dr. Johnson, Executive Secretary of the Food Protection Committee. I suppose we shall always have the publicity seeker who tampers with the facts to serve some selfish aim. I would like to quote from a press release issued by a member of Congress on March 7, 1957:

". . . today poisons are being injected into food without limit, . . ."

"'Agene' was used for 30 years to bleach flour, until the University of Aberdeen, Scotland, found it caused running fits in dogs and affected the mentality of humans. After several years this 'Agene' was replaced with a chemical called 'Alloxan,' a poison used in experimental laboratories to induce diabetes in animals."

"One way to avoid cancer is to not create it by eating poisoned foods."

Are these misleading, untrue and alarming statements worthy of attention? Do they create a problem for the food industry? Should the IFT take any note of them? Such questions lead us to the last session of this panel discussion.[a]

[a] The session referred to will be represented by comment under the title "Our Communications and Education Problems" and will be reported in a sub-sequent issue of *Food Technology*.

Concerning Food Colors

R. D. Gerwe

Food Machinery and Chemical Corporation, Florida Division

As a part of this panel discussion, I have been asked to review for you the current situation with respect to food colors, and particularly those classed as coal-tar colors.

Many of the coal-tar colors have been in use since the early nineteen-hundreds and some even before. Although a system of certification was employed by the USDA before 1938, under the Food, Drugs and Cosmetics Act of 1938, a new system of classifications of these colors was instituted. In accordance with the Act the Secretary of Agriculture was instructed by Congress to "promulgate regulations for the certification of coal-tar colors which are harmless and suitable for use in foods." Identical statements were given separately for drugs and cosmetics.

Accordingly, three separate classifications were set

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Glycerine has already been applied in solutions for freezing by direct contact, experimentally here —commercially abroad. In other types of food applications its acceptability has long been a matter of record.

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up, colors permitted for use in foods, drugs, and cosmetics were designated as FD&C colors; those for use in drugs and cosmetics, but not foods, as D&C; and those permitted for use only in external drugs and cosmetics as External D&C colors. Selection and certification of these dyes was based upon specifications of purity and adequate showing of safety by animal feeding studies.

Delisting of FD&C Orange No. 1, Orange No. 2, and Red No. 32. To all intents and purposes, this system of certification has served the best interests of the public and industry very well. However, in 1953, 15 years after the passage of the 1938 Act, Hearings were started on certain of the colors and as a result, early in 1956, three of them—FD&C Orange No. 1, Orange No. 2, and Red No. 32 were removed from the FD&C list and re-listed under the External D&C list.

Public Law No. 672. The proposed de-listing of FD&C No. 32 was of great importance to the citrus industry of Florida and Texas because this color has been utilized since 1938 to color oranges shipped to the fresh market. Since that date, some 300,000,000 boxes of oranges have been so colored and sold without any adverse results whatsoever.

In 1935 Congress recognized that the use of color to provide the exterior of oranges with a uniform color to a degree equal to the maximum natural varietal color, is a necessary and legitimate practice as applied to oranges meeting full maturity standards, and according to the U. S. Dept. of Agriculture was a practice which should be encouraged.

It has been shown that the amount of color on such color-added oranges is only 4 p.p.m. based upon the total weight of the fruit, and is on the outer peel only and not in the edible portion. It was shown also that for a person to ingest an amount of color equal to that fed to animals at a level of 0.1% in their diet, a person would have to eat 2,250 oranges or approximately 1,000 lbs.—per day—peel and all.

Dr. Allmark and co-workers of the Department of National Health and Welfare of Canada have shown the "no-effect" level of FD&C Red No. 32 to be 300 p.p.m. Equivalent to this, a person could eat 675 color added oranges per day—peel and all—without any adverse effect from the color.

U. S. Food & Drug concurred that "there is no evidence that in the amounts used, and in the manner of use, in the coloring of oranges, the product so colored is not safe for human consumption."

In order to protect the interests of the Florida and Texas citrus industries, Bill HR 7732 was filed by Congressman Haley of Florida during the latter part of 1955 and on July 9, 1956 became Public Law No. 672. This Law provides for the continued use of FD&C Red No. 32 (now External D&C No. 14) until March 1, 1959. The purpose of the law is:

1. To provide time to find a substitute color which is more acceptable to U. S. Food & Drug, and
2. Presumably to provide time to investigate the possibility of setting up a system of quantitative limits on the amount of color in foods.

Proposed de-listing of FD&C Yellow No. 1, No. 2, No. 3, and No. 4. The May 4, 1957 issue of the Federal Register published a Proposed Order of FDA, to delist FD&C Yellows No's. 1, 2, 3, and 4. Any person who would be adversely affected by the Order had 30 days from that date to file written objections and to request a public hearing. In the absence of a hearing, the Order will become effective 90 days after May 4th and the colors will be re-listed for use only in external drugs and cosmetics.

Until recently there were 19 colors on the list of FD&C dyes. If these four are removed, there will be only 12 left and no oil soluble ones.

Proposed new definition of coal-tar colors. The term coal-tar colors has for many years been defined as a color which is produced from a coal-tar chemical or chemicals, or which is capable of being produced from that class of chemicals.

In the Federal Register of January 24th, of this year, it was proposed by FDA that this definition be modified to exempt certain natural pigments. There was also a separate proposal that synthetic pigments chemically identical to natural pigments be exempted.

The present definition undoubtedly is obsolete, for with the advances made in chemical synthesis, many substances can be made and are being made from chemicals obtained from coal. The name *coal tar* is, however, a misnomer and has aquired a bad connotation. This is true also of the designation—chemicals in foods. In reality there is no sharp line of demarcation between chemicals produced from coal, petroleum, or from vegetable origin. Coal and petroleum are in fact of vegetable origin. It seems rather elementary and certainly scientifically correct that all food colors should be required to meet the same general standards of purity and of pharmacology. So far, the definition has not been officially changed. It seems scientifically proper that the designation, coal tar should be discontinued, and that all colors which are to be used in foods should be classed as "food colors" and should comply with the same yard stick of standards.

COLORS IN FOOD—QUANTITATIVE ASPECTS

In recent years, since 1953, the *per se* doctrine of harmless has come into being. The phrase "harmless and suitable for use" has been employed since at least 1900 and apparently even before then, and yet was never given an official definition. Dr. Calvary, Chief of the FDA Department of Pharmacology during the early 1940's, did state officially that he interpreted "harmless" to mean *harmless in the amounts and manner of use.* It was known that the FD&C colors would produce adverse effects in feeding tests at very high levels relative to normal usage.

In hearings which preceded passage of the 1938 Act, Dr. Calvary testified that all of the colors in the certifiable list were safe as used in foods, and of course in drugs and cosmetics.

During 1955, an ad hoc Committee was appointed by the National Academy of Sciences, at the request of FDA, to study FDA's research program on coal-

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tar dyes. With respect to the harmless *per se* doctrine of zero toxicity at all levels, this Committee rendered the following opinion:

> "This is unrealistic unless the level of use is specified, because rigid interpretation of the law would render uncertifiable many components of ordinary diet. Attempts to conform to such an idealistic standard of absolute safety serve to direct research along unproductive lines."

It is recognized that nothing is absolutely harmless, not even salt or vinegar. The LD/50 of salt is reported to be 4 g. per kilogram of body weight; yet we would not class it as a poison.

The total quantity of FD&C dyes certified per year is approximately 1,500,000 lbs. Part of this is used in drugs and cosmetics, part is exported and part is used in foods which are exported. Even so, assuming that all of it were consumed in foods in this country, based upon consumption of 1,500 lbs. of food per capita per year, this would amount to only 7 p.p.m. of color in all of our food. Of the total 1,500,000 lbs., approximately 170,000 lbs. consists of oil soluble colors. This represents, therefore, only about 0.8 p.p.m., on the basis of total food consumption.

Unfortunately there have been public references to cancer in connection with coal-tar colors. These have been improper and without correct foundation. Many animal feeding studies have been made, but no evidence has been found to indicate that any of these colors in foods cause cancer. All tests were negative.

The National Academy of Science has stated, "Scientific conjecture on possible cause and effect relationships can be an effective device in development of new knowledge concerning disease. However, when scientific discussions have been reported to the general public, the conjectural nature has frequently been forgotten, misconstrued, or poorly stated; this has contributed apprehension among consumers over the safety of foods and concern among food manufacturers over possible loss of consumer confidence."

Comments of E. H. Volwiler. At the recent meeting of the American Drug Manufacturers Association, President E. H. Volwiler, who is also President of Abbott Laboratories said, "The drug industry, which thus far, has held aloof from the debate over proposed food additives legislation, should take a very close look at what is developing." He commented that the enactment of a new coal-tar colors certification statute seems probable, and he urged that all drug makers take an active part as new legislation comes closer. He stated further:

"The demand for pharmaceutical elegance of dosage forms constantly increases." he pointed out, "so that we are more and more dependent on the availability of a wide choice of colors. We must, therefore, make sure that regulatory burdens are not greater than necessary to protect the public health."

He went on to suggest that the term "coal-tar color" be dropped, regardless of what form the new law takes. Chemical synthesis has advanced so far, he said, that it is frequently a matter of economics or supply whether the raw materials are derived from coal tar, petroleum or a natural plant source. Thus, he held, the term "coal tar" in this context has no special meaning.

"As the law is presently written," he declared, "there is the implication that a color so related in chemical structure to a constituent of coal tar as to be capable of derivation from it is particularly suspect. This anachronism should not be perpetuated."

It is recognized that there can be abuses with virtually anything. Certainly where there is a chance of excess through ignorance, carelessness, or through unscrupulous intent, means should be set up to prevent such abuse. Work is being done in an effort to set up a system of quantitative limits for use of colors in foods. Dr. R. Sherwood who is a member of the Color Manufacturer's Committee has kindly agreed to give us a report on this.

Report of Dr. Sherwood. Dr. Sherwood (Sterwin Chemical Company) emphasized that pharmacological studies were conducted on all of the listed food colors prior to the 1938 Act, and the results were considered to adequately demonstrate their harmlessness and their safety. He said that the Color Manufacturer's Committee is working with FDA and is drawing up proposed legislation to set up quantitative limits (tolerances) on colors in foods. He feels that they are making progress but can make no predictions as to when such legislation will be enacted.

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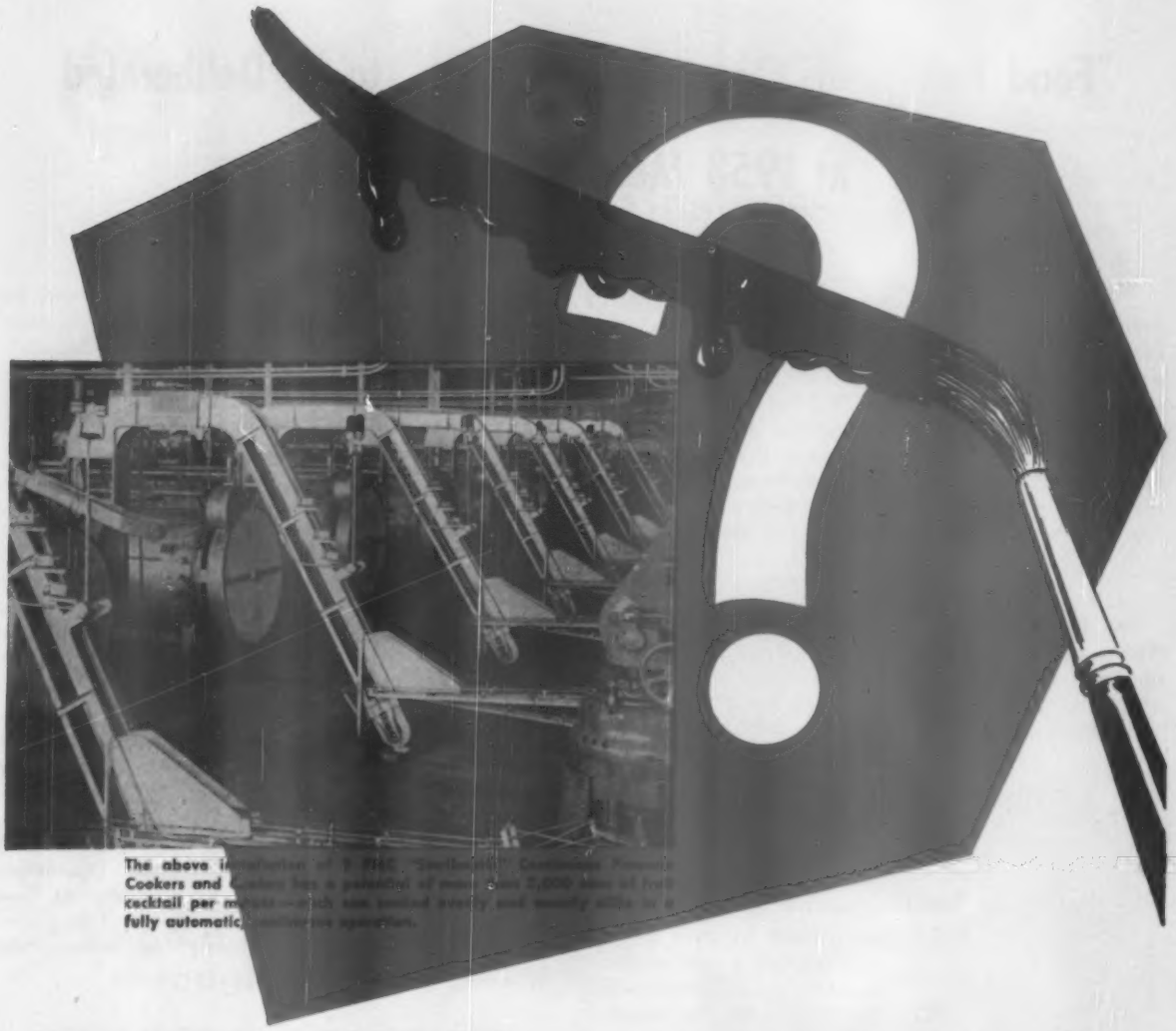

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"Food Fats" and "Operations Research" to be Deliberated at 1958 Meeting in Chicago

At a recent meeting of the Program Committee for the 18th Annual Meeting of IFT (Chicago, May 25-29, 1958) plans for two symposia were firmed up. "Food Fats" will form the subject of one sympoisum and "Operations Research" of the other. Co-Chairmen Jackson and Beach in announcing the symposia emphasize that those who have an interest in both topics will be able to attend the two symposia since one will be held in the morning and the other in the afternoon of May 29.

Symposium on Food Fats

Dr. E. E. Rice, in charge of Nutrition Research, Swift & Co., Chicago, will conduct the Symposium on Food Fats. The program will bring together in one session information corncerning the quantitative, qualitative, and economic importance of fats. Additionally, as now planned, the processing procedures to which natural fats are subjected and the importance of fats to nutrition and health will be discussed. Speakers of high competence in their fields will furnish a perspective on this widely publicized subject, giving a proper share of their attention to the possible, though not yet proved, relationship of dietary fat to atherosclerosis. The opinions of prominent nutritional and medical groups will be reviewed. Although a symposium cannot hope to settle the many scientific controversies over the role of fat, the IFT Symposium on Food Fats will be unique in its effort to present the whole picture (1) the supply aspects, (2) the physiological need, (3) the dietary problem, and (4) the economic implications. Admittedly an ambitious program, the speakers (to be announced after the program has been fully organized) are capable of fulfilling the demands of the subject. This should be an outstanding symposium.

Symposium on Operations Research

The topic of the second symposium to be held on May 29th is equally in the scientific news.

Operations Research is a comparatively new management advisory service whereby scientific analysis is applied to operational as opposed to purely technical problems. A representative project would be establishing by the tools of mathematics planting schedules for growers so that the flow of products after harvest would come to the processor evenly rather than first in trickles and then in gluts. Dr. J. M. Jackson, Associate Director of Research, American Can Company, Barrington, Illinois, will serve as Chairman of this Symposium. The applications of Operations Research to various phases of the food industry will form the subject of the Symposium.

As tentatively designed, the scope of the program will include the planning and scheduling of production, the operations research approach to purchasing, the optimum control of inventory as well as many other areas. Operations research is already being used by a number of food industry enterprises to neutralize the effect of uncertainties in planning, purchasing, and production operations.

Important Current Aspects of Food Additives — a Panel Discussion

With Dr. Frank L. Gunderson, Consultant, Washington, D.C., as moderator, a panel discussion of important current aspects of food additives, a half-day session, will be held on Wednesday, May 28, 1958. It is expected that the legislative status of an amendment to the Food, Drug and Cosmetic Act, safety-evaluation procedures and interpretation as well as recent and forthcoming national and international conferences on food additives will be considered. Outstanding experts will be invited to constitute this panel. The Institute has been most fortunate in recent years in obtaining for its annual meetings expert analyses of the status of food additives. The panel discussion to be

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led by Dr. Gunderson at the 18th Annual Meeting (Chicago, May 25-29, 1958) will continue this fine service to the food industry in general and to food technologists in particular.

Technical Sessions

A recapitulation of the technical sessions and their respective chairmen follows:

1. **Radiation Preservation of Foods.** Dr. H. W. Schultz, Oregon State College, Food Technology Department, Corvallis, Oregon
2. **Canning.** Mr. W. E. Pearce, American Can Company, Research & Technical Department, Maywood, Illinois
3. **Frozen Foods.** Mr. G. V. Hallman, Campbell Soup Company, Research & Development, Camden, New Jersey
4. **Meat, Fish and Poultry.** Mr. C. K. Wiesman, Armour & Company, Research Division, U. S. Yards, Chicago 9, Illinois
5. **Cereal and Bakery Products.** Dr. P. E. Ramstad, Technical Director, Products Control Department, General Mills, Inc., Minneapolis, Minnesota
6. **Citrus Products.** Mr. H. W. Trumm, Libby McNeill & Libby, Ocala, Florida
7. **Dehydration.** Mr. R. W. Kueneman, J. R. Simplot Company, Caldwell, Idaho
8. **Packaging.** Mr. L. J. Hayhurst, Kraft Foods Company, Research Laboratories, 923 Waukegan Road, Glenview, Illinois
9. **Food Engineering.** Mr. G. A. Crapple, Wilson & Company, Inc., Research & Technical Division, 4100 S. Ashland Avenue, Chicago, Illinois
10. **Instrumentation.** Mr. J. H. Bock, Continental Can Company, Process Engineering, 1350 W. 76th Street, Chicago 39, Illinois
11. **Prepared Foods for Military Use.** Dr. R. G. Tischer, Quartermaster Food and Container Institute, 1849 W. Pershing Road, Chicago 9, Illinois
12. **General Research Papers.** Dr. C. O. Chichester, University of California, Food Technology Department, Davis, California

Dr. H. W. Schultz (left) Oregon State College, Corvallis, chairman of the Radiation Preservation of Foods session, and Mr. Trumm (right) who heads the Citrus Products meeting.

Mr. R. W. Kueneman, J. R. Simplot Company, Caldwell, Idaho, and Dr. C. O. Chichester, University of California, Davis, California. Dr. Chichester leads the general research session and Mr. Kueneman (left) that on dehydration.

DEADLINES

Titles of Papers: December 1, 1957.

Abstracts: January 1, 1958.

Where to send: To the chairman of the appropriate session.

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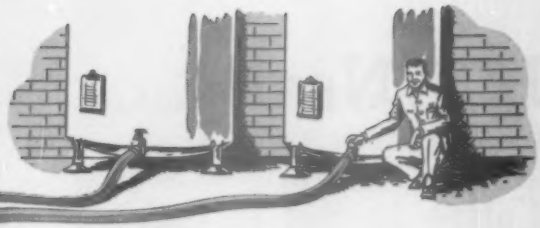

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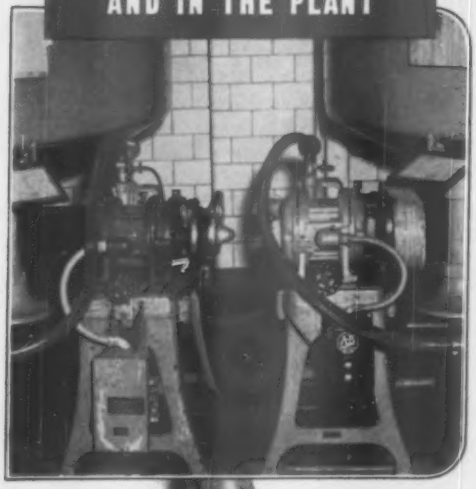

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Coffee to this Instant*

Kenneth T. Farrell
Corn Products Refining Co.,
New York, N. Y.

LEGEND HAS IT that the stimulating effect of coffee was first discovered by an Arab herdsman, watching over his flock of goats. As night fell, he noticed that the spirits of the goats did not. As a matter of fact, they seemed to have *more* pep and paused only long enough from their merry making for an occasional frisky and goatish nibble from a nearby berry bush. This intrigued the herdsman. He took his observation to the priest of the local monastary for an explanation. There were no Food Technologists to turn to in those days. Now, it seems as though the priest had a related problem. Midnight prayers were somewhat of a problem for his particular Order. He was having a difficult time keeping the monks awake at that sleepy hour. After listening to the herder's tale, the priest, who must have been the deductive type, figured that whatever the goats were nibbling on stimulated them. On a hunch, he went and picked himself a basketful of the sun-dried berries and made a brew. Shortly after drinking it, his wits were sharpened. He felt nimble, alert, happy. "Just the thing for my drowsing monks," the priest concluded. At midnight the brew was brewed and the priest and his monks took part in the world's original coffee break. The sparkling career of coffee had begun.

Dr. Kenneth T. Farrell . . . addresses Chicago Section

This was not coffee as we know it, for how could the priest have known what a wonderful difference roasting the berries would have made. The Arabs, however, were quick to realize the value of this new commodity and planted extensive coffee holdings which soon brought them great riches. As they wanted to monopolize the world's supply of coffee, they roasted the coffee beans before exporting them in order to kill the germinating powers of the beans. Thus, it appears that roasted coffee was an accident or by-product of monopoly. The dictionary calls this sort of thing "serendipity."

The history of coffee as it developed through Arabia, Persia, Turkey, and the old European world is rich in legend and makes fascinating reading. Coffee made a new way of life for the English, bringing the men out of their homes into public places with companions of mutual interest. The Englishman and his club are inseparable to this day, but few remember that it was coffee houses that began this custom. Across the ocean, America's fundamental principles of liberty and government were being discussed in the coffee houses of the Colonies. These small beginnings grew to the point where America, today, consumes two-thirds of the whole world's supply. Three billion pounds of green coffee beans are imported annually! Unless you have worked for the Government, it may be difficult for you to visualize 3 billion of anything. But if you were to place end to end the 132-pound bags of coffee, they would stretch westward from the Palmer House here in Chicago to Bombay, India, 11,500 miles away.

Do you know that Americans percolate, boil, drip or filter 180 billion cups of coffee a year? That's enough coffee to fill a pool 1 mile in diameter and 55 feet deep. "The dollar value of coffee dwarfs any other imported product or commodity that the United States purchases, including petroleum, tin, wheat, sugar, and any cereal, grain, fiber, metal, or mineral that you might care to name. As a commodity it determines the political, social and economic welfare of millions of people in many producing countries. Coffee is big business—enormous business.

Background. There is much variation in quality among the many kinds of coffee which are imported into the United States. Each variety is classified according to its area of production, grade, and quality. No single variety of coffee makes a beverage equal to one made by skillful blending. Commercial coffees are separated into two general groups known as *milds* and *Brazils*. The latter are known by names taken from the exporting ports or the regions in which they are grown. In the order of market popularity they are referred to as Santos, Paranas, Minas, Bahias, Pernambucos, Rios, and Victorias. Mild coffees can be nearly any other coffee produced in the world except some African varieties. *Milds* include Columbians, Mochas, Javas, Mexicans, Abyssinians, Hawaiians and so forth.

*Presented before the Chicago Section of the Institute of Food Technologists at the Palmer House, Chicago, April 8, 1957.

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Coffee found its way into the military feeding system as a standard item of issue in 1832 when President Jackson authorized the substitution of 4 pounds of coffee and 8 pounds of sugar per 100 rations for half a gill of rum, brandy, or whisky. (There are probably quite a few men in the Service today who would like to see this authorization rescinded.) Though instant coffee is considered by many to be a comparatively recent innovation, the Armed Forces have displayed a keen interest in various kinds of coffee concentrates for almost a hundred years. For instance, the Congress of the United States authorized the Secretary of War in July of 1862 "to commute the Army ration of coffee and sugar for the extract of coffee combined with milk and sugar, to be procured in the same manner, and with like restrictions and guarantees, as preserved meats, pickles, butter and desiccated vegetables are procured for the Navy, if he shall believe it will be conducive to the health and comfort of the Army and not more expensive to the Government than the present ration and if it shall be acceptable to the men." (Sounds very much like the Army's present day policy on foods—doesn't it?)

On June 12th, 1865, two months after President Lincoln's assassination, the United States Patent Office issued to L. D. Gale of Washington, D. C. "a Patent on an Improved Process for Preparing Coffee." I was fortunate in being able to obtain a copy of this patent, and I would like to quote three or four short paragraphs for I know you will find them of interest.

"The nature of the invention consists in extracting from roasted coffee all the soluble parts of the same, including the volatile aroma contained therein and putting the whole into the form of a dense and solid cake that may be handled and packed without being inclosed in cans or their equivalents and mixing the same with sugar or sugar and milk in the manner hereinafter described:

"It requires no paraphernalia of coffee pots and strainers to prepare it. Although hot water is preferable to cold water, it is by no means indispensable as either [hot or cold] makes a very desirable drink.

"As this coffee was invented for the use of the Army and Navy to aid the soldier and sailor in situations of exposure, where coffee as ordinarily prepared could not be procured, and often where neither hot nor cold water can be had, then the soldier or sailor in the heat of battle or the soldier in the midst of a weary march or watching may withdraw his dry coffee cake from his knapsack or pocket and chew and swallow a half ounce of the cake, which will mix with and melt in the saliva of the mouth without any drink whatsoever and is equivalent as a restorative to the system to a half pint of strong coffee. In transportation the coffee cake saves seven-tenths of the weight of the coffee and one-half of the bulk of the coffee and sugar together. This cake is therefore especially adapted to the wants of the Army and Navy where reduction of bulk and weight are important considerations."

There is something rather remarkable about this excerpt from the archives of the past. Aren't we preaching the same gospel today? This claim was written 95 years ago and we are still talking about saving shipping space and weight, eliminating utensils, providing food that is acceptable to the troops cold or hot, etc.

Soon after the turn of the century, the idea of soluble coffee began to catch on—at least among the manufacturers. Soluble coffee was used to a limited extent, in fact, in the operational rations of World War I. But due to its objectionable flavor, it never became very popular. However, by the time of the outbreak of World War II, the flavor of soluble coffee had been developed to the point where it was at least not repulsive. The nature of the war was such that it was absolutely impossible to have fresh coffee in many places and hence "soluble" was a small contribution to logistics. Great credit is due Colonel Rohland A. Isker, who is with us this evening, for the impetus in stimulating the industry to expand and improve on its product. The role that the Food and Container Institute has played in its development ever since is worthy of putting on the records.

Know-how and know-why at work. Those of you who have been in my former office may remember seeing a circular green plaque on the wall with only one word inscribed thereon: Why? That word is a thought provoker. Why am I doing this or that? Why should we work on this or that project? Why soluble coffee? Was it not tried over and over again and found wanting? Why bother trying to change the drinking habits of the Armed Forces?

Ladies and gentlemen, in 1949 I honestly believed, as I do tonight, that soluble coffee will some day replace fresh coffee in all retail outlets. Everything is in its favor. In 1949 only two principal objections were raised against it—its poor flavor and the poor consumer attitude toward dehydrated foods in general. Each of these objections has since been overcome.

Going back to the first objection again, numerous opinions have been expressed by exports and laymen alike both for and against instant coffee. Except for mounting sales figurs, which I shall discuss later, few factual data have been published to indicate the acceptability of instant coffee from the point of view of quality. One of the purposes of this presentation is to disclose for the first time, results of actual extensive taste tests which have been conducted since 1949 and attempt to illustrate that today, instant coffee is

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Competition and food emulsifiers

Ever since the day two men started offering the same food product in the same market place, the food manufacturer has had to make a choice—either say his wares cost more because they are better, or find a way to make them better and yet cost the same or less. More businesses have been built on the latter than the former.

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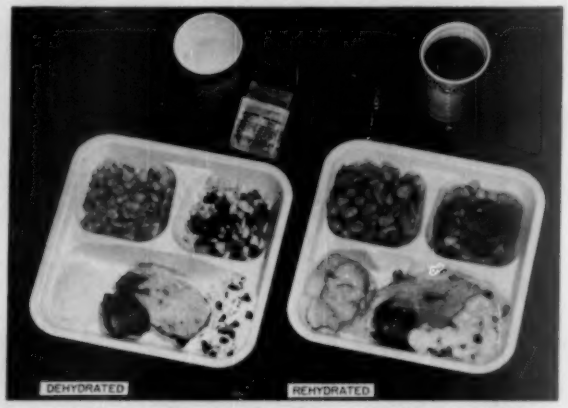
preferred by the consumer to the average freshly roasted and ground coffee, when she or he does not know which coffee is being served. Before I do this, let me go over some of the preliminaries. The quartermaster Food and Container Institute goes to great lengths to insure that when instant coffee is procured for the Armed Forces it will be highly acceptable to



Instant coffee is an important component of the new quick-serve meals proposed for future military feeding systems

the men. The basic requirement for this insurance is, of course, an adequate specification. This "spec" is not prepared by one or two armchair technologists but by the best qualified men in the country, the Research and Dvelopment Advisory Committee on Instant Coffee. Such men as Charles Kaufman, former Research Director for the General Foods Corporation and now Vice President of the Kraft Foods Corporation; Harold Levenson, Manager of the Maxwell House Division of General Foods; Mr. George Harrison, President of the Harrison Coffee Company; Frank Lanigan, Manager of Product Development for the Nestlé Company; Mr. Mook and James Hale from the Borden Company; Dr. Lawrence Atkin, Research Director for Standard Brands; Mr. Morrow and Mr. Filz from the Tenco Company; Mr. Alcock and Mr. Fletcher Chase from the George Washington Division of American Home Foods; Dr. Radov from Jewel Tea Company, and many others. No one present tonight will dispute the reputation of these men or the companies which they represent. Since December of 1949 we worked intimately with this committee and benefited thereby from their experiences and expenditures. Over ten million dollars have been expended by these companies in the past six years on research and developmnt of instant coffee—and I hasten to add that the Armed Forces played a very vital role in accelerating coffee research.

One of the first tasks of the committee was to establish uniform testing procedures for moisture, caffeine, and reducing sugars, and then to establish minimum or maximum levels of these components as criteria for judging coffee quality. Caffeine is extracted out into the brew at the early stages of percolation. The longer the extraction, the less the caffeine in proportion to the total extracted solids—and the greater the amount of carbohydrates. Thus, by controlling the ratio of

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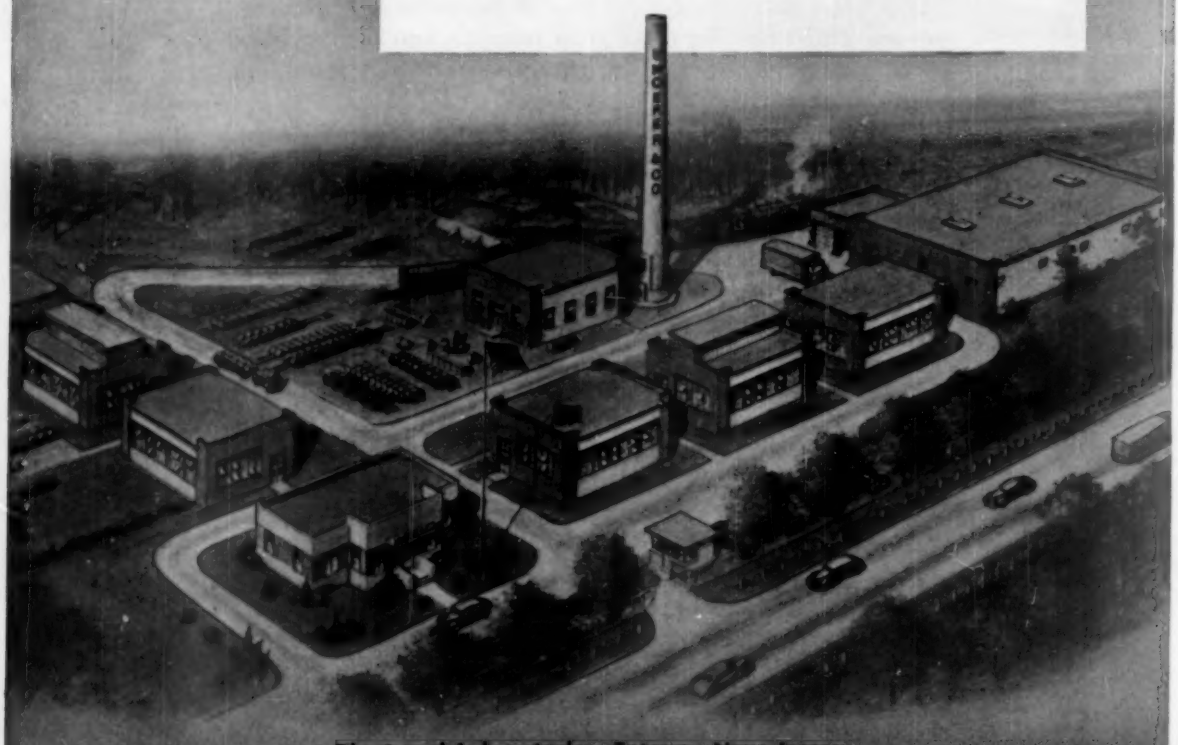

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Pigment Changes in Packaged Beef During Storage[a, b]

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Food Processing Laboratory, Iowa State College, Ames, Iowa

(Manuscript received April 30, 1956)

PRESENCE OF DESIRABLE COLOR is one of the important factors determining acceptance of meats. Since color has been identified with freshness, the consumer relies on this criterion of quality to provide him with a product which he considers satisfactory.

Fresh cut meat contains myoglobin in a reduced form. Due to the great affinity of myoglobin for oxygen, brightening of the cut surface occurs upon exposure to air for a short period of time. Mackintosh and Hall *(21)*, Allen *(1)*, and Bratzler *(5)* pointed out that oxygenation or "blooming" of meat occurs very rapidly within the first 30 minutes after cutting and is accelerated by reducing the temperature.

Oxygen uptake is not restricted to the surface of the meat. Brooks *(6, 7, 8, 9)* demonstrated that the depth of oxygen penetration in muscle was determined by the rate of diffusion of oxygen into the tissue and by the consumption of the gas by the tissue. Given sufficient time, a steady state was reached, such equilibrium depending upon temperature, partial pressure of oxygen, time of storage, and conditions of the penetrated muscle. Brooks found that increasing temperature tended to decrease the oxygen penetration while higher partial pressures of oxygen or prolonged time of exposure caused a deeper degree of tissue penetration by oxygen. Maximum depth to which oxygen diffused into the tissue was found to be about one centimeter. Brooks concluded that the discoloration of meat was restricted to this relatively thin superficial penetrated zone. In earlier work Brooks *(7)* observed that when he had covered the slices of beef with thin glass plates, the muscle pigments acted in a very characteristic way: the middle of the slice showed a purple color with an adjoining zone showing brownish discoloration. He reasoned that the purple region consisted of reduced hemoglobin (myoglobin) and the brown zone was composed largely of methemoglobin (metmyoglobin). This ring zone phenomenon was also observed by Coleman *(12)* who offered an explanation on the basis of critical oxygen pressure.

Darkening of meat due to desiccation has been attributed to changes of the pigments and to their "concentration" on the surface of the meat. According to Urbain *(27)*, such darkening of meat was caused by concentration of the pigments as a result of the loss of water. Kraft and Ayres *(18)*, in discussing color changes of packaged sliced fresh meats, made a distinction between discoloration due to oxidation of pigments and that due to loss of water from the tissues. Penrod and Baker *(23)* found that an increase in temperature as well as in air velocity accelerated dehydration and discoloration of beef samples and that these changes were reduced as the relative humidity in the air increased. These same workers pointed out that if unwrapped meat samples were exposed to air, surface discoloration proceeded more rapidly than total dehydration during the first few hours after exposure.

Kraft and Ayres *(18)* used a spectrophotometer to take reflectance measurements of packaged fresh beef and expressed their findings as per cent mean reflectance at eight wavelengths selected in the region from 540 to 800 mμ. These workers observed that the reflectance of beef when wrapped with MSAT 80-cellophane differed considerably from that of samples wrapped with a laminate of cellophane and polyethylene.

Reflectance curves of fresh meat in the visible light region were reported by Ginger *et al. (15)* and the meat pigments identified in accordance with existing reflectance maxima. These last workers stated that the reflectance curves obtained with a Beckman DU Spectrophotometer confirmed the presence of discolorations observed visually while absorption curves from pigments extracts of similar samples did not give any indications about the pigment changes on the surface of the meat.

In the present study the use of reflectance spectrophotometry to observe pigment changes was undertaken in order to determine the influence of different packaging materials on the discoloration of fresh meats.

EXPERIMENTAL

For studies involving discolorations it was found essential to use meat of uniform color. Some degree of success was achieved in accomplishing this objective by taking meat from animals of similar age, from the same parts of the carcass, and from the same muscle sections. However, even when these precautions were followed, the results were not always satisfactory. It was found that meat having a pH value greater than ph 5.7 was generally dark in color; also, very light meat — which apparently came from young animals — was unsatisfactory for comparative purposes.

Animals from which meat was procured were graded "U. S Choice" and at the time of slaughter were estimated to weigh from 900 to 960 lbs. The post-mortem age of the meat at time of sampling ranged from 3 to 6 days. Steaks of approximate ½ in. thickness were fresh-cut from the round and transported to the laboratory; in no instance was the time that elapsed between cutting and subsequent trimming in the laboratory greater than 30 minutes. It was found that the *biceps*

[a] Journal Paper No. J-3205 of the Iowa Agricultural Experiment Station, Ames, Iowa. Project No. 1264.

[b] Presented at the 17th meeting of the Institute of Food Technologists, Pittsburgh, Pennsylvania, May 13, 1957.

[c] This paper is an abstract of the thesis submitted by Paul C. Pirko in partial fulfillment of the degree of Master of Science in Food Technology at Iowa State College, July, 1956. Present address is Vienna, Austria.

femoris and the *semimembranous* muscles showed the most uniform color. These 2 muscle portions of each slice were cut into pieces 3 x 2½ x ½ in. in size.

Meat was stored in an open-type meat display case held at a temperature of 6° C. ± 1° C. except for defrost time. During the daily defrosting period the temperature rose to 12° C., but did not remain above 7° C. for more than 2 hours. Care was taken to assure that the several samples in a series were held under identical conditions of temperature and humidity and were exposed to equal amounts of light. An automatic recorder was used to check temperature fluctuations; also wet and dry bulb hygrometers were placed in various parts of the display case. A recording hygrograph was used to check humidity readings. Light intensities in the display case were measured with a General Electric Type DW-68 light meter calibrated in foot candles. Dark storage was provided in a refrigerator which kept the temperature at 5° C. ± 1° C.

Pieces of meat were allowed to "brighten" by exposing to air in the refrigerator for 25 minutes; then the surface to be exposed to light was covered with a single layer of packaging material. Excess film or foil was folded and sealed on the underside of the package.

Packaging materials used in this study were selected to represent wide variations in gas permeability and water vapor transmission. According to a discussion given in the *Modern Packaging Encyclopedia (22)*, these materials can be classified as having:

High gas and high water vapor transmission:
Cellulose-acetate gauge 100, 300 MSAT 80-cellophane

High gas and medium water vapor transmission:
80 FM 1-Pliofilm

High gas and low water vapor transmission:
Polyethylene 0.0015 in.

Medium gas and medium water vapor transmission:
120 HM 1-Pliofilm

Medium gas and low water vapor transmission:
Polyethylene 0.0020 in.

Low gas and medium water vapor transmission:
450K 202-Saran coated cellophane

Low gas and low water vapor transmission:
517 Saran gauge 50, Aluminum foil 0.0015 in., 0.0004 in. foil, 0.0075 Saran laminate (FX 831), Cryovac bag (standard and high shrink)

A Wells-type hand sealer, style TF, with automatic temperature control was used for sealing the heat sealable or shrinkable films. By placing a Teflon backed glass cloth between the hot plate and the film, this heat sealer could be applied also to Saran and polyethylene films, producing a "peelable" type seal. Samples packaged in aluminum foil and laminates of films and foil were sealed by folding the end of the wrapper several times and tying down this fold with Scotch masking tape (No. 202). Packages wrapped in Saran and polyethylene were also given a final seal with masking tape.

A Cenco Hyvac vacuum pump was used to evacuate the samples packaged in Cryovac. Samples were placed in bags, evacuated, twisted while under vacuum, and a rubber band applied to the gooseneck twist to keep it closed during storage. For meat packaged and evacuated in Cryovac, the film was shrunk by dipping the sample into hot water (99° C.) for approximately 1 second. Otherwise all of the samples in Cryovac were kept under conditions similar to those employed for the other packages.

The following intervals were selected for storage time and for sampling: 0 hours, 8 hours, 1, 2, 3, 4, 6, 8, 10, 12, and 14 days. Additional samples were examined during the first day in studies set up to determine oxygen penetration. In these experiments and in the series prepared to test the influence of the initial state of meat on the subsequent color changes, meat was wrapped immediately while still in the reduced condition without allowing it to brighten or "bloom" in the refrigerator. For determining depth of oxygen diffusion, the packaged piece of meat was cut through in vertical direction with a sharp knife and the depth of the zone subject to color changes measured in millimeters.

After the desired time of storage had elapsed, reflectance measurements were taken immediately after the meat was unwrapped. A Beckman Quartz Spectrophotometer, Model DU, equipped with a diffuse reflectance attachment, Model 2580 was used for these determinations; a block of U. S. P. carbonate of magnesia served as the standard. A strip of polystyrene Q-641 film was placed over the meat held in the reflectance attachment in order to prevent meat particles from adhering to the attachment housing. Reflectance curves were obtained by recording values in 5-10 mμ intervals within the range 460-650 mμ; percentages of reflectance in the Soret region were so small (approximately 0.5-2%) that these values were not used. Values obtained were plotted as per cent spectral reflectance vs. wavelength. Reflectance measurements at wavelength of 555, 580, and 635 mμ provided the basis for securing information on the pigment interchanges occurring during storage. The per cent reflectance at each of the 3 wavelengths was characteristic for the central area of the meat samples and not for any discoloration that occurred at the edges.

In order to ascertain that maximal reflectance values were due to pigments and not to the pigment carrier, the reflectance of pigment-extracted meat substance was evaluated. Meat was deep-frozen and cut into slices approximately 0.1 inch in thickness by use of a Hobart Model 411 Meat Slicer. These thin slices were thawed in warm water and freed of pigment by extraction with 2% KCl solution. When the slices appeared gray-white in color (generally within 12 hours), they were removed from the solution, dried on the surface, and their reflectance values in the range from 460 to 650 mμ obtained.

Loss of moisture was determined by differences in weight. A torsion balance (± 4 mg. sensitivity) was used and the initial weight of each packaged sample was taken before storage and the weight of the sample was taken daily and calculated as per cent of initial weight.

For studying weight loss in terms of sample thickness, 2 series of meat samples of the same size but of different thickness were kept in the display case. Packaging materials used for this study were 300 MSAT 80-cellophane and cellulose-acetate gauge 100; thicknesses of the meat in these series were ½ in., 1 in., and 2 in.

RESULTS AND DISCUSSIONS

Before selecting wavelengths that could be used to determine differences in pigment concentrations on the surface of beef, it was necessary to obtain spectral reflectance curves. This was done with fresh beef exposed to air for 25 minutes and with beef from which the pigment had been extracted with KCl (Figure 1). Four absorption maxima (reflectance minima) can be seen at the wavelengths 500, 545, 580 and 635 mμ; also there is a minimum value shown at 555 mμ. According to Theorell (*(25, 26)*, Kiese and Kaeske *(16)*, Bowen *(4)*, and Ginger *et al. (14)*, these peaks may be attributed to the pigments metmyoglobin (500 and 635 mμ), and oxymyoglobin (545 and 580 mμ), while a minimal value at 555 mμ coincides with the absorption spectrum for myoglobin. Range of variation in these values is shown by the solid line while median value is indicated by dotted lines.

The reflectance spectrum for pigment-extracted meat indicates much higher reflectances than does fresh meat. In the extracted meat at the lower wavelengths per cent of reflectance is less than at 635 mμ; peaks for myoglobin, oxymyoglobin and metmyoglobin are not apparent. In order to present figures with slopes indicating an increase in concentration of the pigment in question, the reflectance scale (ordinate) was inverted.

Reflectance values were found to be high for beef

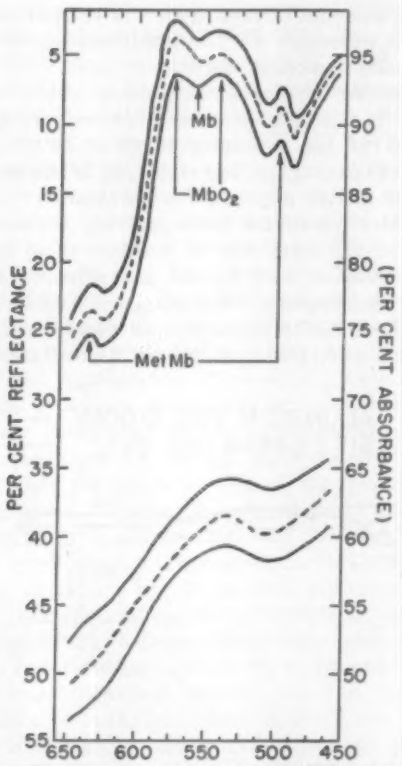

Figure 1. Reflectance curve for fresh and KCl extracted beef.

extracted with KCl in the region 500-580 mμ (58-61%) while with fresh beef the values were quite low (2-4%). There was considerable variation in the amount of pigment present in meat obtained from various samples but extraction of the pigments resulted in a grayish-white appearance of the remaining meat substances in all instances. Therefore, a low content of pigment would be the cause for the pale appearance of meat and for increasing spectral reflectance at all wavelengths as the color approaches white; a large part of the variation of the reflectance values among fresh and packaged samples of beef might be explained on this basis.

Reflectance values for meat packaged in 300 MSAT 80-cellophane, 80 FM 1-pliofilm, 0.0015 in. polyethylene, and 517-Saran (gauge 50) and stored for 6 or 14 days are shown in Figure 2. Similar percentages of

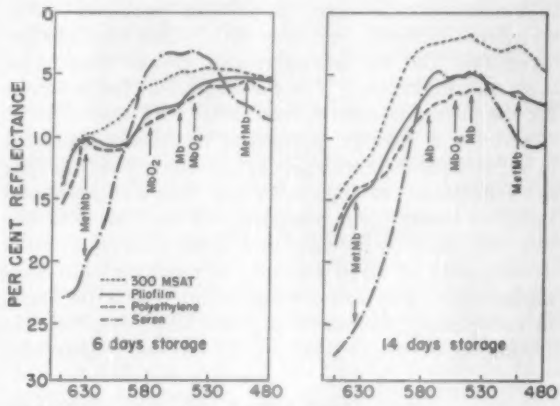

Figure 2. Effect of storage on reflectance readings made on packaged beef.

reflectance were observed at the wavelengths characteristic for metmyoglobin formation — 500 and 635 mμ, for meat that had been packaged in cellophane, pliofilm, and polyethylene and stored for 6 days. However, for meat packaged in Saran quite different metmyoglobin readings were obtained. Evidently cellophane, pliofilm, and polyethylene, while limiting diffusion of oxygen, provide sufficient partial pressures to permit excellent conditions for the formation of metmyoglobin. Since Saran is highly impermeable to diffusion of oxygen, the pressure is so low that, after the free air within the package has been depleted, insufficient oxygen passes through the film for the formation of additional metmyoglobin.

After storage for 14 days, meat packaged in 300 MSAT 80-cellophane gave low reflectance values at all wavelengths. This was due not only to diffusion of oxygen through the film but in part at least to concentration of the pigment as a result of desiccation (also see Table 1). It was noted that meat packaged in Saran would still "bloom" even after 14 days of storage and that its reflectance pattern was more like that of fresh meat after storage for this period of time than were those for the more permeable films after 6 days of storage.

Figure 3 illustrates the changes in reflectance at 555 mμ, 580 mμ, and 635 mμ during storage for meat wrapped in cellophane, pliofilm, polyethylene, aluminum foil or saran. The pattern of the curves indicates

TABLE 1
Weight changes of beef packaged with various materials

Packaging material	Storage time (days)								
	1	2	3	4	6	8	10	12	14
Cellulose acet. No. 100	5.6	14.6	19.2	30.2	37.0	50.1	58.0	61.2	63.5
300 MSAT 80-cel.	1.4	3.3	5.2	7.2	10.2	13.7	17.5	21.0	22.7
80 FM 1-Pliofilm	0.3	0.8	1.2	1.6	2.5	3.4	4.2	4.5	5.7
450 K202-Sar.c.cel.	0.2	0.5	0.9	1.4	1.7	3.4	4.3	5.2	5.8
120 HM-Pliofilm	0.3	0.4	0.7	0.9	1.4	1.8	2.0	2.4	2.8
Polyeth. 0.0015 in.	0.1	0.3	0.4	0.6	0.9	1.2	1.5	1.8	2.0
Polyeth. 0.0020 in.	0.1	0.1	0.3	0.4	0.6	0.8	0.9	1.1	1.3
FX 831	0.1	0.1	0.3	0.3	0.6	0.6	0.7	0.9	1.0
517 Saran No. 50	0.0	0.1	0.1	0.2	0.3	0.5	0.7	0.8	1.0
Alum. foil 0.0015 in.	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8
Cryovac evacuated	0.1	0.1	0.1	0.2	0.3	0.3	0.4	0.6	0.7

[1] Expressed as per cent of inital weight. Average of 40 samples for each packaging material.

that minimal reflectance at 635 mμ (maximal metymyoglobin content) coincides with higher readings for myoglobin and for oxymyoglobin (lower content of these two pigments). The differential in the readings for the metmyoglobin of fresh meat with that of meat stored for 6 days in cellophane represents a change in reflectance of more than 16%. Since meats having low reflectance readings at 635 mμ were discolored and failed to bloom upon reexposure to air, this information was used to indicate that films which permitted development of large amounts of metmyoglobin were undesirable. For example, although meats packaged in cellophane, pliofilm or polyethylene permitted the formation of the typical scarlet red color associated with the presence of free oxygen in beef, after 3 to 6 days this coloration was lost and was replaced by the brown color typical of old meat.

Apparently a direct relationship exists between maxima in metmyoglobin formation and the gas permeability of the packaging material to be applied. Among the packaging films employed in this study, the following groups appear to be represented: (a) films with which maximum metmyoglobin formation occurred on the sixth day of storage; these consisted of the materials with highest gas permeability (300 MSAT 80-cellophane, Polyethylene 0.0015 in. and 80 FM 1-pliofilm); (b) a group with which maximum formation took place on the 4th day of storage, in-

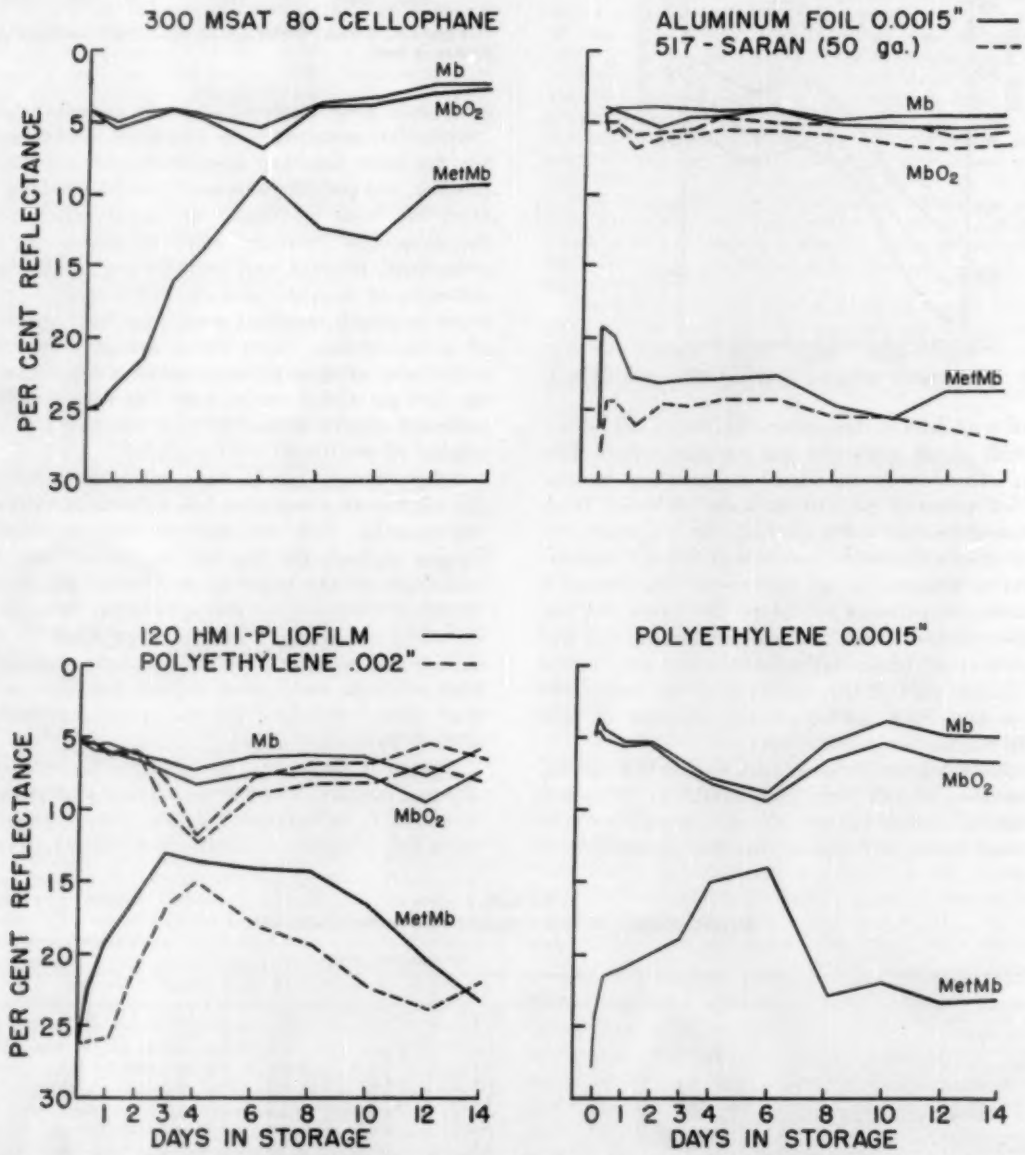

Figure 3. Changes in per cent reflectance[1] during storage of packaged beef at wavelengths characteristic for metmyoglobin (635 mμ), oxymyoglobin (580 mμ), and myoglobin (555 mμ).

[1] Each value represents the mean reading for 6 different samples of meat.

cluding films with medium gas permeability (120 HM 1-pliofilm, polyethylene 0.0020 in.); (c) the group with which maxima in metmyoglobin were observed on the first day of storage. This group was represented by aluminum foil, 517-Saran, Cryovac, 450K 202-Saran coated cellophane and FX 831. When meats were packaged in films having low permeability to gases, there was a sharp increase in the amount of metmyoglobin formed immediately after packaging, but within 2 to 4 hours there was no further increase and at the end of 1 day there was an appreciable reduction in the total amount of metmyoglobin content. Regeneration of myoglobin and oxymyglobin appeared to take place during storage.

The first appearance of browish discolored spots or areas of higher metmyoglobin concentration was randomly distributed on the meat surface. During subsequent days of storage these discolored areas spread until the entire surface of the meat was uniform in color. It may be noted that the content of oxymyoglobin shows simultaneous increases and decreases with those of myoglobin. This observation may be explained by the general pigment reaction scheme that formation of metmyoglobin influences the equilibrium between myoglobin and oxymyoglobin. Before metmyoglobin can be formed, oxymyoglobin must dissociate into oxygen and myoglobin. Myoglobin, in turn, is oxidized to the ferric pigment so that a change in metmyoglobin content results in a reciprocal change in concentration of oxymyoglobin and of myoglobin.

The observation that conversion of metmyoglobin to myoglobin takes place when meat is packaged in films having low rates of gas transmission leads to the conclusion that the reducing activity of muscle is suffcient to keep the meat pigments in a reduced state throughout the storage period when packaged in film such as saran, saran laminate, cryovac, or aluminum foil. Films such as saran-coated cellophane and 0.0015 in. aluminum foil, which have similar rates of gas transmission but different rates of water vapor transmission, exert about the same effect on meat pigments. It appears that insofar as color changes are concerned, oxygen transmission through the packaging material may be of more importance than water vapor transmission provided that water losses do not cause the meat to be severely desiccated. Warburg *(28)* showed that muscle tissues retain a certain respiratory activity after the "death" of the animal that results in a continuous consumption of oxygen. If, therefore, there is a constant demand for oxygen, insufficient migration of this gas through the film or foil leads to its eventual depletion.

George and Stratmann *(13)* have demonstrated that the rate of metmyoglobin formation is dependent upon oxygen pressures. Therefore, one might postulate that, with films such as are shown in Figures 3 and 4, a critical oxygen pressure may be reached on the surface of the meat on the first day, after 4, or after 6 days of storage according to the packaging material in question.

Weight loss of the meat after a given storage time in relation to the packaging material applied is shown in Table 1 and Figure 5. While loss of moisture from the meat was related to the size and thickness of the sample, desiccation of the surface layer was much less dependent upon sample thickness. Apparently the rate of evaporation from the surface tissues is greater than the rate of water migration from the inner portion of the sample to the surface. Scott *(24)* stated that ox muscle retained its full water content when stored at 99.3% relative humidity but lost weight when stored in atmospheres containing lower moisture levels.

Effect of desiccation on the reflectance values for unwrapped meat or for meat packaged in cellulose-

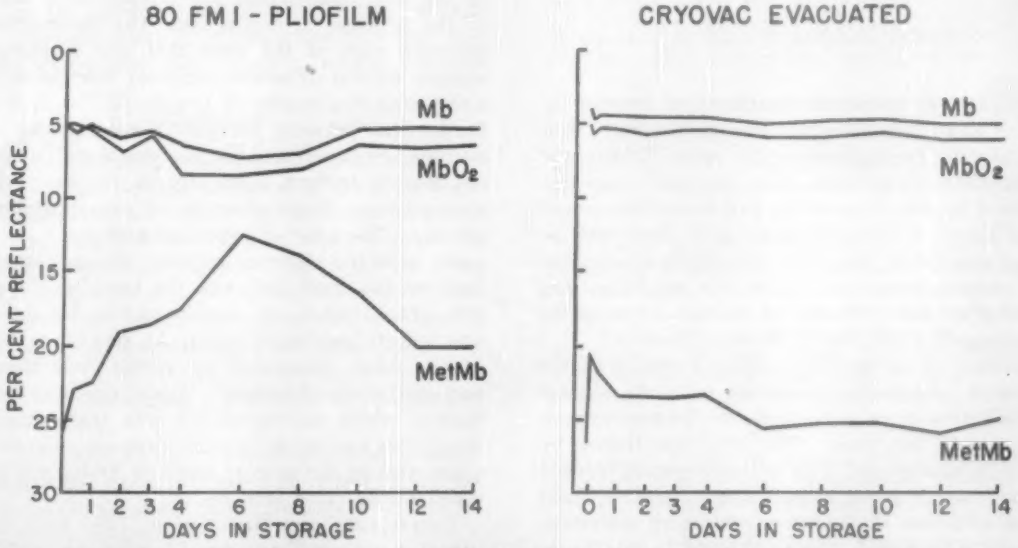

Figure 4. Changes in per cent reflectance at wavelengths characteristic for metmyoglobin (635 mμ), oxymyoglobin (580 mμ), and myoglobin (555 mμ) for beef packaged in 80 FM I-Pliofilm or in Cryovac and evacuated.

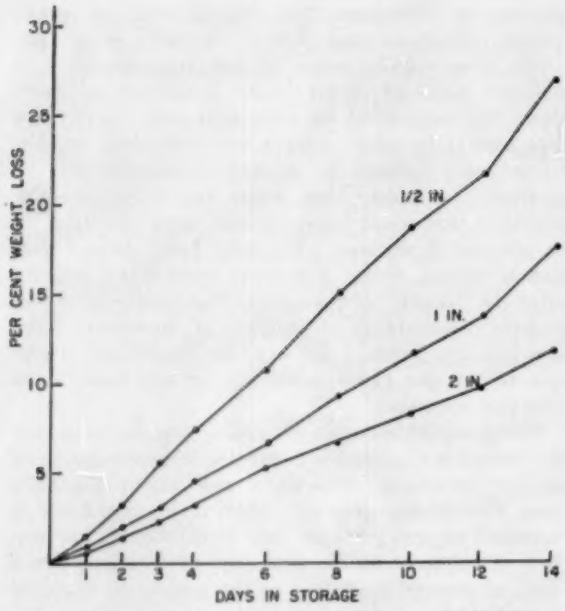

Figure 5. Effect of storage time on weight losses of beef of ½", 1", or 2" thickness when packaged in 300 MSAT 80-cellophane.

TABLE 2
Effect of storage time on reflectance values for beef stored unpackaged or packaged in cellulose acetate

Storage time	% Reflectance at:		
	555 mμ	580 mμ	635 mμ
Unwrapped beef			
0.0	3.7	4.6	21.8
0.5 hours	4.3	4.4	24.9
1.7 hours	3.9	4.0	24.2
7.5 hours	3.0	5.5	20.4
1 day	3.2	5.5	11.5
Beef packaged in cellulose acetate (100 gauge)			
2.5 hours	3.5	3.9	23.0
8.0 hours	3.5	3.9	20.5
1 day	2.8	3.2	15.0
2 days	2.4	2.8	9.5
3 days	3.0	2.8	8.7

acetate (Table 2) indicated simultaneous decrease in the values at all 3 wavelengths due, presumably, to a concentration of the pigments in the meat. Reflectance values for times longer than those reported could not be obtained because desiccation had become so severe that the samples changed shape and could not be measured accurately using the reflectance attachment of the spectrophotometer. A similar condition was observed after the 10th day of storage when meats were packaged in 300 MSAT 80-cellophane.

Penetration of oxygen into packaged meat is shown in Figure 6. Packaging materials with the highest permeability to gases permitted the deepest oxygen migration into the meat. The zone penetrated by oxygen in meat wrapped with cellulose-acetate reached a constant depth much more quickly than in meat wrapped with one of the other packaging materials. Of the materials tested, those not listed in this figure failed to show an oxygenated zone of measurable depth

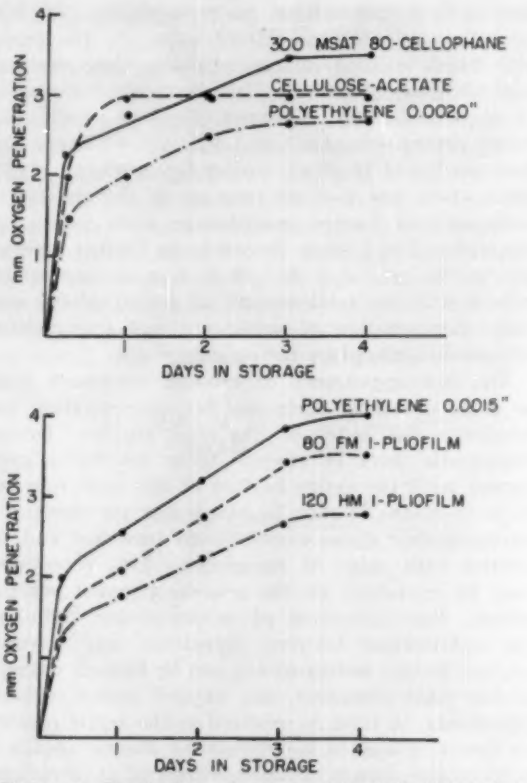

Figure 6. Penetration of oxygen into beef packaged in various films.

in the meat; meat wrapped in gas impermeable materials presumably remained in the reduced state throughout the storage period.

Maximum depth of oxygen penetration was reached after 4 days of storage. This zone was subject to changes in color while the remaining inner portion of the meat maintained the purple color indicative of the presence of myoglobin. The observation that only the part of the meat that was penetrated by oxygen showed detectable pigment changes is in harmony with the results of Brooks *(6, 7, 8, 9, 10)*. The border line between the part penetrated by oxygen and the non-penetrated portion was always of uniform depth and distinct, especially in the early days of storage when large amounts of oxymyoglobin were present. The color of these zones changed simultaneously with the observed pigment changes on the surface of the meat and was the same as the surface color noted when the metmyoglobin formation had reached its maximum level. At this stage the part of the meat penetrated by oxygen was thoroughly and uniformly discolored. Upon continued storage, during which metmyoglobin was transformed into myoglobin and oxymyoglobin, pigment reduction took place also in the zone penetrated by oxygen as indicated by its color change.

Lavers *(20)* and Butler *et al. (11)* have used absorption spectrophotometry for pigment extracts and have associated their findings with surface discolora-

tions without defining the size of the samples in question. However, the above results demonstrate, unless the thickness of the examined sample is exactly defined, absorption spectrophotometry cannot be applied in determining discolorations of meat that are restricted to the superficial layers only. Further, consideration must be given to the effect of desiccation on the relative concentration of the pigment at different times of storage.

Allen *(2)* has postulated that for commercial packaging of meats a film having a water absorptive surface and low water vapor transmission should be used. However, Ayres *(3)* found that meats packaged with MSAT cellophane developed off-odor more quickly than they did in a laminate of pliofilm and aluminum foil. Kraft and Ayres *(17)* advanced the concept that fresh beef wrapped with highly gas impermeable films kept myoglobin in the reduced state through a storage period of 12 days and that "blooming" of the meat took place upon subsequent exposure of this meat to air. These last-named workers recommend the use of gas impermeable packaging materials in order to prolong storage life of meat. Landrock and Wallace *(19)* stated that meat samples wrapped in films with gas permeability above 5500 ml. oxygen/square meter/24 hours maintained the desirable bright red oxymyoglobin color for 48 hours. Urbain *(27)* and Bratzler *(5)* thought that vacuum packaging, although widely in use for cured meat products, would have a very undesirable effect on the color of fresh meat but did not present laboratory evidence to support their opinion. The results obtained in the present study do not support this concept. Apparently, fresh meats packaged and stored in gas impermeable films reoxygenate to give the desired oxymyoglobin for periods as long as 12-14 days when stored at 4.4° C.

The problem of determining the role of the various factors which govern the discoloration of packaged meat is still not resolved. Certainly the gas permeability of the wrapper and the respiratory activity of the packaged meat or of the organisms that contaminate its surface must receive further consideration.

SUMMARY

Reflectance spectrophotometry was used to measure spectral changes on the surfaces of beef packaged in different materials. From the minimal reflectance values observed, the wavelengths characteristic for myoglobin, oxymyoglobin and metmyoglobin were identified and, after storage for 14 days in a refrigerated display case, pigment changes were confined to the wavelengths characteristic for these three pigments.

At 635 mμ, packaging materials could be divided into three groups:

(a) Those with which the concentration of metmyoglobin increased upon prolonged storage and did not reach a maximum until the sixth day—300 MSAT 80-cellophane, polyethylene 0.0015 in., 80 FM 1-pliofilm. Since reflectance values for these pigments reached a minimum of 8-14 per cent by the sixth day, the films were considered to be the least satisfactory of all that were tested.

(b) Those with which maximum metmyoglobin formation occurred on the fourth day of storage—120 HM 1-pliofilm, polyethylene 0.0020 in. With these films reflectance values were in the 13-18 per cent range on the fourth day of storage.

(c) Those with which maximum metmyoglobin formation occurred on the first day of storage—aluminum foil 0.0015 in., FX 831, 450 K202-saran coated cellophane, 517-saran (gauge 50), cryovac (evacuated and evacuated and shrunk). There was least metmyoglobin formation with these packaging materials. Minimal reflectance values of 19-24% were obtained on the first day of storage and could not be detected after that time. Also, regeneration of desired pigment formation of meats packaged in these materials was possible for periods as long as 14 days. In every case reformation of myoglobin was accompanied by a decrease of metmyoglobin. Vacuum packaging of fresh meat did not result in greater discoloration than that taking place with other packaging films belonging to group *(3)*.

Maximal values for metmyoglobin were observed to occur at the same time that minimal oxymyoglobin and myoglobin concentrations were obtained.

Desiccation of packaged meat was found to depend upon the thickness of the meat cuts, the loss of weight being inversely proportional to the sample thickness. Excessive loss of water resulted in a hardening of the surface of the meat and a simultaneous increase in all reflectance values.

Reducing activity of the muscle tissues and gas permeability of the packaging material were important factors governing spectral changes.

LITERATURE CITED

1. Allen, N. Color changes in fresh meat. *Pre Pack Age*, (Nov.) p. 9. (1948).
2. Allen, N. Meat film considerations. *Modern Packaging*, **22** (Jan.), 134 (1949).
3. Ayres, J. C. Some bacteriological aspects of spoilage of self-service meats. *Proc. Conf. Res. Am. Meat Inst.*, **3**, 39 (1951).
4. Bowen, W. J. The absorptions spectra and extinction coefficients of myoglobin. *J. Biol. Chem.*, **179**, 235 (1949).
5. Bratzler, L. J. Technical problems in pre-packaged fresh and frozen meats. *Proc. Conf. Res. Am. Meat Inst.*, **7**, 62 (1955).
6. Brooks, J. Changes in muscle-pigments. *Reports, Food Invest. Board*, Gt. Britain, p. 27 (1929a).
7. Brooks, J. Post-mortem formation of methaemoglobin in red muscle. *Biochem. J.*, **23**, 1391 (1929b).
8. Brooks, J. Changes in the muscle pigments. *Reports, Food Invest. Board*, Gt. Britain, p. 30 (1934).
9. Brooks, J. The color of meat. *Food Inds.*, **9**, 707 (1937).
10. Brooks, J. Color of meat. *Food Research*, **3**, 75 (1938).
11. Butler, O. D., Bratzler, L. J., and Mallmann, W. L. The effect of bacteria on the color of prepackaged retail beef cuts. *Food Technol.*, **7**, 397 (1953).
12. Coleman, H. M. The mechanism of meat-pigment oxidation. The effect of solutes on the hemoglobin-oxygen equilibrium. Food Research, **16**, 222 (1951).
13. George, P., and Stratmann, C. J. The oxidation of myoglobin by oxygen. 2. The relation between the first order rate constant and the partial pressure of oxygen. *Biochem. J.*, **51**, 418 (1952).

14. Ginger, I. D., Wilson, G. D., and Schweigert, B. S. Quantitative determination in beef and pork muscle and chemical studies with purified metmyoglobin. *J. Agr. Food Chem.*, 2, 1037 (1954).
15. Ginger, I. D., Lewis, V. T., and Schweigert, B. S. Changes associated with irradiating meat and meat extracts with gamma rays. *J. Agr. Food Chem.*, 3, 156 (1955).
16. Kiese, M., and Kaeske, H. Verbindungen des Muskelhamoglobins. *Biochem. Z.*, 312, 212 (1942).
17. Kraft, A. A., and Ayres, J. C. Post-mortem changes in stored meats. IV. Effect of packaging materials on keeping quality of self-service meats. *Food Technol.*, 6, 8 (1952).
18. Kraft, A. A., and Ayres, J. C. Effect of display case lighting on color and bacterial growth on packaged fresh beef. *Food Technol.*, 8, 290 (1954).
19. Landrock, A. H., and Wallace, G. A. Discoloration of fresh red meat and its relationship to film oxygen permeability. *Food Technol.*, 4, 194 (1955).
20. Lavers, C. C. Discoloration of packaged red meat. *Modern Packaging*, 21, 125 (Jan.) (1948.
21. Mackintosh, D. L., and Hall, J. L. Some factors related to color of meat. *Am. Soc. of Animal Production Proc.*, 28, 281 (1935).
22. *Modern Packaging Encyclopedia.* Properties of packaging films. Packaging Catalog Corp., New York (1954).
23. Penrod, B., and Baker, M. Effect of storage conditions on drying and discoloration of beef. U. Kty. Eng. Exp. Sta. *Bull.* 39 (1954).
24. Scott, W. J. The growth of microorganisms on ox-muscle. I. The influence of water content of substrate on rate of growth at –1° C. *J. Council Scient. Ind. Res.*, 9, 177 (1936).
25. Theorell, H. Kristallinisches Myoglobin. 3: Die Absolute Lichtabsorption von Oxy,-Carboxy,-Meta,-und Reduziertem Myoglobin. *Biochem. Z.*, 268, 55 (1934a).
26. Theorell, H. Kristallinisches Myoglobin. 5: Die Sauerstoffbindungskurve des Myoglobins. *Biochem. Z.*, 268, 72 (1934b).
27. Urbain, W. M. Facts about meat color. *Nat. Provisioner*, 127, 140 (1952).
28. Warburg, O. Versuche an uberlebendem Carcinomgewebe (Methoden) *Biochem. Z.*, 142, 317 (1923).

Freeze-Drying of Fruit[a]

(Manuscript received May 15, 1957)

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Use of freeze-drying techniques allows the production of low moisture food with comparative ease. The increase in storage stability and aacceptance of freeze-dried low moisture products has been pointed out by several investigators *(1, 2, 4)*. If a fruit product is reduced to below 5% moisture, an increase in storage stability of approximately three-fold at normal storage temperatures can be expected. Freeze-drying, however, is a rather time-consuming operation. Under typical conditions in the drying of halved peaches, the time required to achieve moisture levels of below 5% is 24 to 30 hours. It has been postulated that the limiting factor in the rate of freeze-drying is the rate of heat penetration into the fruit (and Harper and Tappel *(3)* have derived equations relating the time required for drying to the coefficient of heat transfer of the dried product). In the light of these conclusions, a study was made of freeze-drying under different conditions of heat transfer.

[a] Presented at the Seventeenth Annual Meeting of the Institute of Food Technologists, Pittsburgh, Pennsylvania, May 15, 1957.

[b] This paper reports research undertaken in cooperation with the Quartermaster Food and Container Institute for the Armed Forces and has been approved for publication. The views or conclusions contained in the report are those of the authors. They are not to be construed as necessarily reflecting the views or indorsement of the Department of Defense.

EXPERIMENTAL METHODS

The fruit used in this experimentation was harvested at optimum maturity during the summer of 1956. Peaches were torque-pitted, cup-down lye peeled, washed and then frozen as halves. Halves were stored for various times in the frozen condition until used as experimental material.

Four methods of transferring the heat to the fruit were investigated, and all drying experiments with the exception of the ones using dielectric heating were performed in the Stokes freeze-drier.

Freeze-drying using single plate heating. The halves of peaches in a still frozen condition were spread on the heated shelves of the Stokes freeze-drier. These were subjected to a vacuum of approximately 350 microns of mercury while the shelves were raised to a temperature of 40° C. and held at this temperature during the entire drying period. Rate of water evaporation was measured by removing peaches at various time intervals and determining the weight loss. In a second series of experiments, the peaches were diced to approximately ½ in. squares, frozen and placed on the heated shelves and the rate of evaporation determined as before.

Infra-red heating. An infra-red heating source was constructed from four 500-watt General Electric heating lamps which were attached to a frame in such a position that the end of the lenses were 6 to 8 inches away from the fruit. The frame was mounted inside the Stokes freeze-drier above a layer of peach halves which were held on a heated shelf whose temperature was maintained at 40° C. An auto-transformer was connected to the electrical input of the lamps and was used to control the heat input to the peaches. Temperature of the peaches was measured by means of thermocouples placed in various positions within and without the fruit. As in the previous case, the rate of moisture removal was measured by weighing.

Double plate contact heating sources. A two plate heating source was constructed from a commercial two plate grill. Halves of peaches were placed between the heated plates and by adding weight to the upper plate the amount of pressure applied to the fruit could be varied. As in the infra-red heating experiments, temperature in the fruit was measured by thermocouples and the heat input to the fruit controlled by means of an auto-transformer attached to the heating plate. This arrangement simulated the English VCD method of freeze-drying or vacuum drying.

Dielectric heating. A vacuum chamber was constructed of pyrex glass cylindrical in shape, approximately 6 in. in diameter and 8 in. in length. This size allowed it to be placed inside the cavity of a commercially available dielectric range (Radarange). Connections were made to the cylinder so that the pressure within the cylinder could be measured and a vacuum could be maintained. The vacuum line to the chamber passed through a glass trap cooled with dry ice-acetone mixture and acting as a condenser. A diagram of the apparatus is shown in Figure 1. In experiments with this source of heating, rate

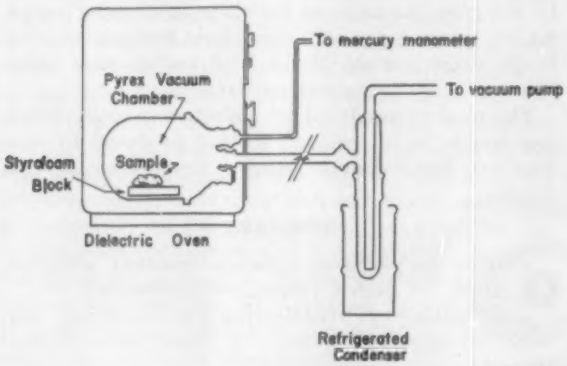

FIGURE 1

of heat input was controlled by varying the plate voltage of the magnitron oscillator in the dielectric range. Actual heat output of tube was measured by determining the temperature rise of a known quantity of water held in a polyethylene container inside the cavity without the presence of the glass chamber. Rate of evaporation of water from objects within the chamber was measured in two ways. Either the gain in weight of the condenser or weight loss of the fruit was used for determination of evaporation rate. Approximate net input of heat to the fruit was determined by noting the amount of water evaporated.

In all of the experiments, the fruit material was reduced to moisture levels below 5%. This figure was taken as a stopping point for the lyophilization.

RESULTS

Figure 2, curve 1, shows the rate of evaporation in the Stokes freeze-drier from halves of peaches on a single shelf maintained at 40° C. Curve 2 shows the rate of evaporation of water from ½ inch cubes held on the same shelf at 40° C. In both cases, the vacuum was approximately 350 microns. Rates of drying using the two plate heating method, infra-red heating and dielectric heating for peach halves are shown in Figure 3. Difficulties in obtaining rates of water loss during the drying period in the Radar-Range limited the number of points obtained for this method of heating.

DISCUSSION

Reduction in size of samples decreases the time required for the moisture removal. The practical

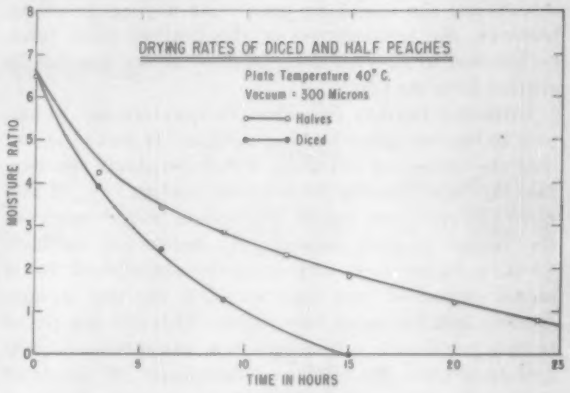

FIGURE 2

limitation of this size reduction comes when the fruit pieces are no longer of a size suitable for re-packaging. In experiments with purees, it was found that the time required for lyophilization increased with increasing tray loading. Initial rate of evaporation was found to be directly related to the rate of heat input to the product. Any method which will increase the rate of heat transfer to the frozen water will increase the rate of evaporation.

Measurements of the resistance of diffusion of the dried material have shown that the rates of diffusion of water vapor through the porous dried mass is extremely high, whereas the rate of heat transfer is extremely low, the porous mass acting as an excellent insulator. These considerations have led us to believe that the coefficient of heat transfer is the rate-limiting factor in freeze-drying.

By adding heat from both sides of the drying sample, the rate of evaporation can be substantially increased as was shown in Figure 3. The limitation of this method, however, is that there is a value above which one cannot drive the rate of heat transfer by increasing the temperature of the plates. This limit occurs when the heating plates are raised to a temperature such that burning or scorching occurs on the dried heated surfaces. Initially, when the pieces of fruit are moist, the temperature of heating plates

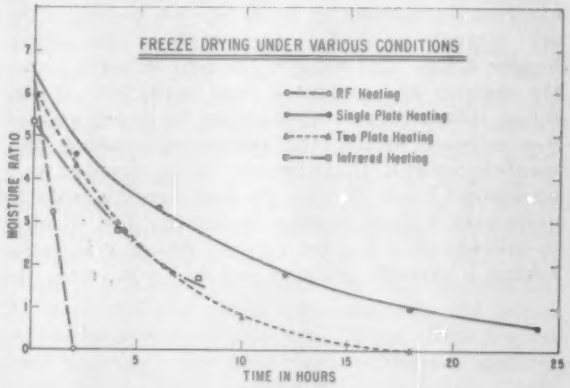

FIGURE 3

can exceed the scorching point. As drying proceeds, however, the temperature of the heating plate must be lowered to prevent deterioration of the samples in contact with the plates.

Infra-red heating experiments were similar in nature to the two plate heating method. It was expected that the infra-red radiation would penetrate the surface layers of the sample to a small extent *(6)*. If this were the case, the major absorption would occur in the frozen portion immediately below the surface. Thus, a higher heat flux could be maintained for a longer period of time than would be the case in conductive heating using two plates. This did not prove to be a substantial advantage as it was extremely difficult to control the surface temperature of the fruit with any degree of precision. In general, it would seem that direct contact heating using two plates would be substantially as good as infra-red heating if the thickness of the material being dried was of ⅜ in. or thicker.

Dielectric heat would seem to offer the possibility of heating in a vacuum while avoiding the difficulties attendant upon conduction heating. The dielectric constant of water in the 2400 megacycle range is high in comparison to most cellulosic materials that would be found in the fruit. In the frozen state, however, this difference is not as large, although the difference allows the selective heating of the unvaporized water without substantially heating the dried product. Initial experiments showed that moderate drying rates could be achieved using this technique. It was found, however, that during the heating process, the decrease in load caused by the evaporation of water from the sample caused an ionization of the residual gases in the vacuum chamber *(5)*. This resulted in point ionization on the surface of the fruit which in turn caused localized burning. Attempts to control this by flushing the chamber at low pressure with other gases, such as air or water vapor, were unsuccessful since these were as easily ionized as the normal residuals. Two methods for avoiding this ionization were found. If fresh loads were introduced as the drying of the initial load occurred, the absorption of energy was sufficient to prevent ionization. In these cases, the secondary samples with their larger water load dried at a more rapid rate. The best method of avoiding the burning by ionization was to reduce the field strength applied to the sample as the sample became drier. This reduced the field strength across the chamber and prevented gross ionization. It was found that a progressive decrease in power applied was necessary as the fruit samples approached 20% moisture content. If the pressure in the chamber were maintained below .05 mm., the field strength could be quite high without causing ionization. The problem in this situation was the extreme difficulty in maintaining a chamber pressure below .1 mm., since the pressure drop across the tubing connecting the chamber to the condenser exceeded the required chamber pressure. If the pressure in the chamber was allowed to rise above 1 to 3 mm. of mercury, ionization was also suppressed. At these pressures, the fruit sample could not be maintained in a frozen condition and hence would collapse. It is thus necessary to operate in pressure ranges below 1 mm. and to decrease the applied power to avoid ionization when drying under vacuum while using dielectric heat. Results of the dielectric heating experiments showed a reduction in the time required for drying of 90% of that required when using conventional single plate heating methods.

Using the apparatus illustrated it was found that approximately 74% of the radiated power from the dielectric source was absorbed in the water of the fruit samples and used directly for lyophilization. The rest of the radiated power was absorbed either by the glass container or the evaporated water vapor. At low power input only very slight heating occurred in the dried sections of the fruit and in most cases, this was below the scorching temperature.

The product produced by dielectric vacuum drying was similar in all respects to that produced by conventional lyophilization using a single plate heating source.

SUMMARY

Peaches harvested at optimum maturity were torque-pitted, lye peeled, frozen, and lyophilized.

Four methods of transferring heat to drying fruit were investigated. Results of these investigations showed:

1. The efficiency of heat transfer limited the drying rates,thus the maximum rates of drying were obtained by dielectric>infra-red>double plate>single plate heating, in that order.
2. With proper controls, freeze-drying by dielectric heating may be accomplished.
3. Conduction heating was as efficient as infra-red heating in sections of moderate thickness.

Of the four methods investigated, the dielectric work seemed the most promising for rapid lyophilization.

LITERATURE CITED

1. Barker, J., Gane, R., Mapson, L. W. The quality of green peas dried in the frozen state. *Food Manuf.*, 21, 345 (1946).
2. Gane, R. Freeze-drying of food stuffs. *Food Manuf.*, 26, 389 (1954).
3. Harper, J. C., and Tappel, A. L. Freeze-drying of food productz. *Advances in Food Research*, 7, 171–234 (1957).
4. Miller, M. W., and Mrak, E. M. (Unpublished data, University of California, Davis, 1955.)
5. Steinhaus, James F. "Glo-Ball" development. *Rev. Sci. Inst.*, 27, 575 (1956).
6. Zamzov, W. H., and Marshall, W. R. Freeze-drying with radiant energy. *Chem. Eng. Prog.*, 48, 21 (1951).

Time-Temperature Tolerance of Frozen Foods.

VIII. Organoleptic Evaluation of Frozen Strawberries, Raspberries and Peaches

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(Manuscript received March 11, 1957)

ALTHOUGH THE LITERATURE on sensory evaluation of food products is extensive, there appears to be no one method or procedure universally preferred above others. At the beginning of our work on the time-temperature tolerance of commercially packed frozen foods, a number of organoleptic procedures were tried for the evaluation of color and flavor changes which occurred in samples held at various temperatures. It soon became apparent that the triangle method was more sensitive than either scoring or ranking, and consequently most of the evaluations were made by this method. The principal problem from a research standpoint was to determine as accurately as possible the time required for the development of deteriorative changes of approximately equal magnitude in the products stored at various temperatures. This requires that in addition to sensitivity the test should give reproducible results which can be easily interpreted.

In general, it has been customary to employ the 5% level of significance to indicate differences between samples or treatments in organoleptic tests. If all the samples in each of the treatments or materials were identical and the tasters were equal and unvarying in acuity, the result corresponding to a 5% level of significance would occur 5 times out of every 100 by chance alone. When it is considered that biological material is not uniform and that individuals differ from each other and are inconsistent with themselves from time to time, it is conceivable that there would, due to these variations, be considerable fluctuation around a result corresponding to a 5% level of significance.

In a triangle test, for example, very slight variations in fruit-to-sugar ratio may influence judges who are exceptionally sensitive to differences in sweetness. Actually these minor sweetness differences have nothing to do with deteriorative changes but they may be sufficient to enable the judges to find a significant difference at the 5% level. Furthermore, differences in sensitivity of judges may allow detection of these minor differences on one day and not the next. In other words, a significant difference at the 5% level in any given test may or may not indicate a true deteriorative change, depending upon variability of material and sensitivity of judges. It is also apparent that under these conditions of variability of material and judge sensitivity a significant difference at the 5% level may not be consistently reproduced during subsequent tests. Obviously, this is of major importance in studies where it is desired to know the time required for a true deteriorative change to develop at a given temperature. For the purpose of this paper a true deterioration is defined as a quality change which the panel as a whole can consistently detect.

In view of the uncertainty of single tests at a given probability level in storage experiments with nonuniform material, it is the purpose of this paper to present a very simple concept of organoleptic evaluation which does not depend on any given probability level or any single test. This concept is ideally suited to studies where differences between control and experimental samples continue to increase with time. The technique requires a sufficient number of tests at any given temperature to establish clearly a definite difference between control and experimental samples when the organoleptic results are plotted against time. Use of this procedure is best illustrated by a hypothetical example. Let us suppose that samples from a given "lot" of material are held at a temperature low enough to prevent deteriorative changes and that these samples are used as controls for other samples from the same "lot" stored at a higher temperature which permits a certain rate of deterioration. Let us further assume that the triangle test is used to determine when a difference occurs between experimental and control samples.

As long as no real deteriorative change develops in the experimental sample, the percentage of correct selections will fluctuate around 33%, the magnitude of the variation depending on sample uniformity, judge sensitivity, etc. If all the judges were equally sensitive, as soon as a definitely noticeable deteriorative change develops we should get 100% correct answers. Furthermore, all tests subsequent to this particular time should also yield 100% correct answers, because the difference between samples would be increasing and it is well known that detection is facilitated as the difference increases. Thus, we would have a situation where the percentage of correct answers would fluctuate around 33% with some individual tests going high enough to be significant at the 5% level, and then when deterioration in the stored sample became detectable as such (as distinguished from guessing) the percentage of correct answers would rise to 100% and remain there without fluctuation.

Under these ideal conditions it would be a simple matter to determine the time at which the curve for correct selections stopped fluctuating around 33% and became stabilized at 100%. This obviously eliminates the uncertainty of individual tests or any given probability level. In practice, however, different judges are not equal and even the same judge will give a different decision on the same sample from time to time. Consequently there may not be a particularly sharp rise from 33% correct answers (chance or guessing range) to 100%. Indeed we may seldom achieve 100% correct answers. As the deteriorative change develops, the more sensitive judges will stop guessing and will select the duplicate samples with certainty, thus increasing the average percentage of correct answers. As the difference becomes larger a greater percentage will be able to select the duplicates without guessing, and consequently the percentage of correct answers will increase either gradually or sharply, depending on the rate of deterioration. Thus at a relatively high temperature we would expect a fairly rapid increase in correct answers because of the high rate of deterioration, whereas at low temperatures we would expect a more gradual rise because of the slow rate of change.

Regardless of temperature, however, a plot of percentage of correct answers versus time will indicate the point where the deteriorative change is sufficiently large to overcome the large fluctuations caused by guessing, material variation and judge variations. After this point has been reached fluctuations in percentage of correct answers will be greatly reduced because the difference due to deteriorative changes is sufficient to eliminate much of the guessing and confusion due to minor variations in material. With a plot of this kind based on at least 6 to 10 separate time intervals, the point at which a true deteriorative change has occurred can be determined more surely by inspection of the entire curve than by relying on the first occurrence of even a highly significant proportion of correct answers. The curve of Figure 1 is an example; attainment of the 3% level of significance for a difference between the flavor of raspberries stored 8 or 9 days at 15° F. and the flavor of control samples was obviously no more than a wide sampling fluctuation. The change occurring in these berries at 15° F. was reaching a real sensory threshold for this panel of judges in the *range* of storage times between about 24 days and 36 days, within which the percentage of correct answers had begun to rise consistently and was high enough to indicate only a very small probability of chance occurrence. This group of tests is discussed in more detail in a later paragraph.

The studies also showed that the reproducibility of separate estimates of the time required to bring about a real sensory change was much improved if the criteria of significance were chosen to be very much better than the 5% or even the 1% probability level. In general, the range of 70 to 85% correct answers was satisfactory. Nothing was gained by computing the extremely low probability levels corresponding

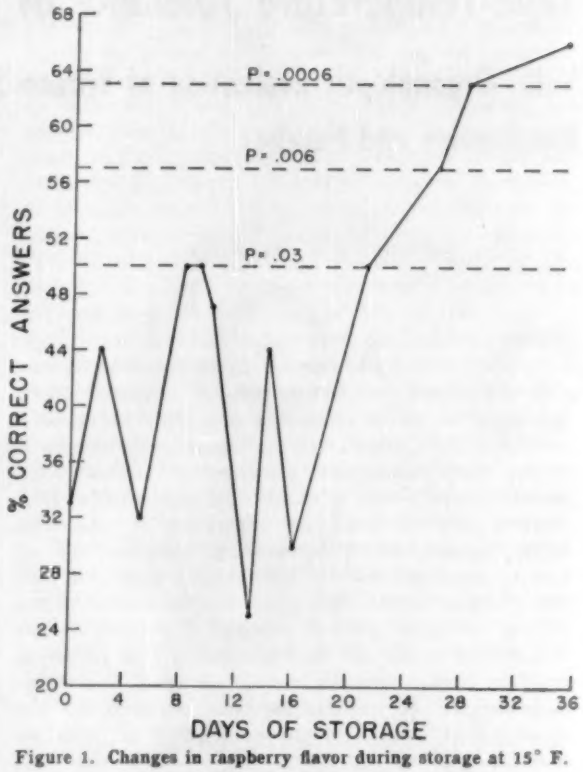

Figure 1. Changes in raspberry flavor during storage at 15° F.

to these percentages of correct answers. Good reproducibility of the time estimate makes it possible to say with some confidence that we are using the same criterion for a "real" quality change today as we were using 3, 6, or 12 months ago. Thus, we are able to determine what lengths of time under various temperature conditions have the same effect on quality. These "lengths of time" are always to be expressed as *a range* of times, because an element of judgment always enters into interpretation of the data, whether the procedure be inspection of the curve of time vs. percentage correct response or choice of a probability level that will be considered "really" significant.

EXPERIMENTAL

Materials used in these experiments were commercial samples of frozen peaches, strawberries and raspberries. Fruit was selected from a uniform "lot" of raw material and processed and frozen in the conventional manner. Frozen samples were shipped to the Laboratory under dry-ice refrigeration and were placed at a steady temperature of −20° F. until subjected to various time-temperature schedules. All control samples from each lot of fruit were maintained at this temperature since it was found that no chemical, physical or detectable organoleptic changes occurred at this temperature for at least 2 years. Since this material was used for time-temperature tolerance experiments, it was subjected to a large variety of time-temperature conditions. Detailed results of these experiments are being reported elsewhere *(1, 2)*. However, for the purpose of this paper only a few examples of typical data will be presented to illustrate the points which have been raised in the introduction. Samples from several different "lots" of material stored at various temperatures were compared with their respective controls at various time intervals.

Continued after Symposium insert

Studies in Food Science and Technology

1. The Methodology of Sensory Testing

Contributions to the IFT Symposium in Pittsburgh

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Committee on Taste Testing and Consumer Acceptance

for the

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Introduction to the Symposium—Background and Scope

Ernest E. Lockhart, Chairman
Committee on Taste Testing and Consumer Preference

TODAY you will participate in a symposium on the methodology of sensory testing.[a] This symposium is the result of several years of thinking, correspondence, and discussion by members of your Committee on Taste Testing and Consumer Preference. It was considered necessary because many papers on sensory testing have been published during the past fifteen years and, although sensory testing and related analysis have shown themselves to be of inestimable value in solving problems involving food acceptance, the great divergence of approach, technique, analysis, and interpretation, so evident in these papers, now requires review and clarification.

One of the most important tasks on which the Committee has had to work has been the preparation of programs for meetings such as these you have been attending this week. These programs have concentrated particularly on providing outstanding research people with an opportunity to present the results of their own investigations without regard for content or direction of purpose except that they both were of high caliber.

These earlier programs have been instrumental in permitting leaders in this field of sensory testing as it applies to food flavor analysis, preference, and general acceptance to provide the food industry not only with new knowledge about the sensory characteristics of foods but also with their personal experiences with methods and modifications of methods.

A powerful and useful tool. They have also provided industry with confidence and assurance that here was a powerful and useful tool for conducting laboratory and development research. To know that this is true, one needs only to look around and count the many sensory testing laboratories now functioning for Governmental, university, industrial and private research groups.

These programs certainly have provided knowledge and, most important, inspiration to younger people about to make a choice of vocational specialty and to others who have felt a desire to know more about the subjective aspects of the food they eat and a desire to reduce subjective opinion to objective measurement and interpretation.

Although these programs in themselves have made a major contribution to the science of sensory testing, they have been supplemented by the work of other individuals, conferences, symposia, and teaching. The rate at which new information is becoming available has been increasing particularly during the past few years, and it is becoming more and more difficult to know what it all means.

It was inevitable, therefore, that the Committee should ask itself—where have we come from, where are we now, and where are we going? It was important to stop for a moment, to take a breath, to look around, to think about, and to sum up the situation as it developed, to find out what it is in order that some conclusion about what is in store in the future might be reached. The Committee suggested a number of ways by which all of this might be done, any one of which would have, to a large degree, achieved its objective. Before the final decision was reached, however, the Executive Committee of the Institute of Food Technologists agreed that one day of its annual meeting should be completely devoted to a discussion of a problem area of prime importance to the food industry. There is no doubt but what our president, Dr. Garnatz,[b] whose interest in sensory testing has always been maintained at a high level, suggested that the first symposium be devoted to taste testing and food acceptance. His suggestion was accepted both by the National Program Committee and by your Committee on Taste Testing and Consumer Preference.

Scope. If you will refer to your program, you will see that only a few aspects of flavor and acceptance methodology will be presented. This is intentional. Each speaker will discuss a specific problem and has been allotted more time than is usual at our meetings in order that the subject may be reviewed, and brought into useful perspective. As a result, a basic methodology, together with techniques for analysis and interpretation of illustrative data, will be provided. There will be ample opportunity for discussion, in which, the Committee hopes, many of you will participate.

The papers will be published as a unit[c]—which will serve as a working reference manual, stimulate further discussion, and provide a base for future modification and development toward a standard and uniform approach to the solution of sensory problems arising in the food industry.

It will be, no doubt, one of the objectives of future committees to process discussion and suggestions stimulated by this symposium and further, to fill in the area not touched upon by our group today. There is still much to be done.

ERNEST E. LOCKHART, Chairman, for the Committee on Taste Testing and Consumer Preference

MR. WILLIAM H. DANKER
MRS. ELSIE H. DAWSON
DR. IRVING S. FAGERSON
DR. DEAN FOSTER
DR. AMIHUD KRAMER
MR. JOHN W. MITCHELL
MR. DAVID R. PERYAM
MR. LOREN B. SJOSTROM

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[a] The contributions to the Symposium on the Methodology of Sensory Testing, contained herein, were presented at the Seventeenth Annual Meeting of the Institute of Food Technologists, the Penn-Sheraton Hotel, Pittsburgh, Pennsylvania, May 16, 1957.

[b] President, Institute of Food Technologists, 1956-57.

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Selection of a Taste Panel for Evaluating the Quality of Processed Milk

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IN THE PAST, threshold tests have been made on water solutions of primary tastes, using a series of different concentrations to determine an individual's taste threshold for *salt, sweet, bitter* or *sour (4, 8, 9, 10)*. As yet, little evidence has been found of a direct relationship between sensitivity to the taste of chemically pure solutions and ability to detect flavor in food products *(8, 10)*. Dilution techniques also have been used in research to evaluate the quality of dried eggs, milk, fruit juices, beverage powders and other products *(1, 2, 5, 6)*. Less frequently these techniques have been used for selecting a taste panel *(7, 11, 12)*.

In 1951, Peryam and co-workers *(11)* used a duo-trio test to estimate the taste threshold of several potential judges. An application of Wald's sequential analysis to sensory taste testing in which the number of samples is dependent on the performance of the taster was presented by Bradley *(3)*. Ranked paired comparison tests were discussed by Terry, Bradley, and Davis *(13)*.

In this study the taste acuity of potential judges was determined for flavors which might possibly be encountered in processed milks. Threshold tests employing dilution techniques evaluated by two different methods of statistical analysis were used in selecting taste panels from two groups of research scientists in the U. S. Department of Agriculture. Making up one group were 10 men from the Dairy Processing Section of the Eastern Utilization Research and Development Division. The second group was composed of 10 women from the Food Quality and Use Section of the Institute of Home Economics (where the functional properties of different market forms of milk are being studied). Some additional taste tests were given the prospective panel members from the Institute of Home Economics.

Threshold tests. Threshold tests were made for four of the more objectionable or prevalent off-flavors sometimes associated with dry milk; namely, (a) proteolytic off-flavor in nonfat dry milk and (b) tallowy, storage, and rancid off-flavors in dry whole milk. Paired samples with and without off-flavor were tested at several levels of concentration.

In this study, the taste threshold is defined as the concentration of reconstituted dry milk at which a taster is just able to detect a difference between a control sample and a test sample. Evaluation of the tasters' judgments followed the method of Peryam and co-workers *(11)*.

Threshold tests were also made on paired samples of evaporated milk and fresh whole milk, and on paired samples of biscuits made with these two milks. An adaptation of Wald's sequential analysis *(3, 14)* was used.

Ranked paired comparison tests. Ranked paired comparison tests for cooked milk flavor were made with fresh milk and two concentrations of evaporated milks processed by two sterilization methods. Data were analyzed following the method of Terry, Bradley and Davis *(13)*.

EXPERIMENTAL PROCEDURES

Preparation of samples. Off-flavored dry milks were supplied by the Dairy Processing Laboratory. The tallowy flavored sample was a dry whole milk canned 13 years ago (1944). Slow oxidation over a long period gave tallowy flavor without development of other off-flavors. The nonfat dry milk with a proteolytic flavor had been stored for a shorter time than the tallowy sample. It may originally have had a high moisture content; this would have furthered proteolysis which gives rise to the characteristic off-flavor. The storage flavor in dry whole milk was induced by unfavorable storage conditions. Storage flavor is not a single off-flavor, but rather a combination of many off-flavors at low concentrations. No one flavor is more prominent than the others. The rancid flavored sample was developed from whole milk made rancid by lipase activity at 120° F. (49° C.) before drying.

Test samples of the off-flavored dry milks were reconstituted with distilled water to give to the experimental product in each case a solids content equivalent to fresh pasteurized whole or skim milk, as required. Fresh homogenized milk, purchased daily from a local dairy, was used to combine with the reconstituted milks in varying proportions for use in threshold tests. The following concentrations of off-flavored milks selected on the basis of preliminary tests were prepared:

Reconstituted dry milk	*Percent concentration*
Tallowy	16, 12, 8, 6
Proteolytic	16, 12, 8
Storage	40, 20, 10
Rancid	12, 8, 4, 2

Since reconstituted dry milk may differ in flavor from fresh milk, 100% fresh homogenized milk was not used as a control but was combined with proportions of good quality reconstituted dry milk to match the dilutions of the off-flavored milks.

Dry milk samples were reconstituted and off-flavor dilutions prepared in the afternoon of the day before the taste tests were given. Samples from one concentration were prepared for a single day's test. Each milk sample was tightly covered and stored overnight in a refrigerator. Approximately 3,000 ml. of each sample was required for the 10 tasters at one session. Ten to 15 ml. of each sample at a temperature of 18° to 21° C. (64° to 70° F.) was poured into 50 ml. beakers coded 1 to 40. Procedures of chilling, holding, and pouring were controlled to allow thorough reconstitution and to maintain satisfactory temperature of the milk samples.

In the threshold tests for the detection of cooked flavor in evaporated milk, a commercial product was used. After dilution to the concentration of whole milk, the evaporated milk in concentrations of 20 and 15% was blended with fresh whole milk. Samples of these dilutions were paired with samples of fresh whole milk. For further tests, drop biscuits were made by a standard formula with fresh whole milk and evaporated milk diluted with equal parts of water. A standardized procedure using an electric mixer and an electric rotary oven was followed in the preparation of the biscuits.

For ranked paired comparison tests on cooked flavor of evaporated milk, two experimental samples of evaporated milk were prepared by the Dairy Processing Laboratory. One sample was processed by high temperature sterilization, 279° to 280° F. (137°–138° C.) for 15 seconds, and the other by the conventional sterilization method, heating to 240° to 243° F. (111.5°–117° C.) for 14 to 15 minutes. The milks were diluted to whole milk concentration with equal amounts of distilled water. Twenty and 40% concentrations of each evaporated milk were then mixed with fresh whole milk to make the test samples. Fresh whole milk was used as the control; thus, ranked paired comparisons were made of 5 experimental samples.

Presentation of samples. For the threshold tests on dry milk, 20 pairs of milk samples, each of which consisted of a control and one level of concentration of off-flavored milk, were presented one pair at a time to each of 10 tasters at each session. Tasters were seated in alphabetical order, at individual tables numbered 1 to 10, facing in one direction. Each pair of samples, served on individual trays to each person, was randomized with respect to the beakers and with respect to the tasters for each session. All persons began tasting each pair of samples at the same time. Tasters were asked to indicate which sample of the pair had more off-flavor. Distilled water at room temperature was provided the tasters for rinsing the mouth. A 4- to 4½-minute interval elapsed between the tasting of each pair of samples. A 10-minute intermission was allowed following the tasting of the first 10 pairs.

Test samples for threshold tests on commercial evaporated milk—20% and 15% dilutions—were presented in random order paired with a sample of fresh whole milk. Tasters were given 10 pairs at the 20% level for 1, 2, or 3 days until the taster was accepted or rejected. If accepted, he was then tested at the 15% level.

In taste tests of biscuits, 7 pairs of biscuits made with commercial evaporated and fresh whole milk were presented to 8 tasters for 1, 2, or 3 days depending on the result of each day's test. The number of tests was determined by an adaptation of Wald's method of sequential analysis (3, 14).

Two groups of tasters, 10 men and 10 women, participated in ranked paired comparison tests for detection of cooked-milk flavor. The statistical design adopted was a paired comparison design as reported by Terry, Bradley, and Davis *(13)*. As the experiment consisted of 5 treatments, samples were presented in all possible pairs on each day. Each sample was thus paired with every other sample twice per session. A total of 10 pairs was given to each of 10 tasters at each of 4 sessions (2 sessions daily). A 10-minute intermission was allowed following the tasting of the first 10 pairs of samples. The samples were arranged and presented in a manner similar to the first threshold experiment. Samples were coded 1 through 40 and pairs were presented in different random order to each taster at each session. A different random order was used for each taster at successive sessions. The tasters were asked to record the number of the sample which had more cooked flavor.

RESULTS AND DISCUSSION

In the threshold tests on dry milk for each of the 4 off-flavors selected (tallowy, proteolytic, storage, and rancid), the concentration at which a taster identified correctly 15 out of 20 pairs was considered his estimated taste threshold. Under the null hypothesis that the proportion of correct identifications made by a taster is 50%, there is a 5% probability that the taster will correctly identify 75% of the samples. The null hypothesis is therefore rejected if a taster correctly identifies 75% or 15 out of 20 pairs, and it is inferred that the taster can differentiate between the samples. Examples of a taster's ability to identify the 4 off-flavors are illustrated in Figure 1. A correct identification is defined as the selection of the sample containing reconstituted dry milk as the one which has more off-flavor than the control sample. If no concentration resulted in exactly 15 correct selections, the threshold was found by interpolation. Because of time limitations, the number of concentration levels used in this study was necessarily restricted.

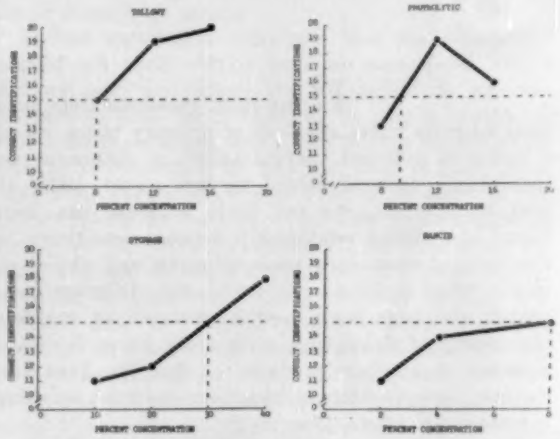

Figure 1. Determination of a taster's estimated threshold for off-flavors in dry milk.

In the selection of a 6- or 8-member panel from the tasters who participated in these tests, two criteria were applied: 1), the mean rank of each taster's threshold, equal weight being given to each of the 4 off-flavors tested; 2), the number of times a taster was in a group of the first 6 persons with lowest estimated thresholds. The lowest concentration of each off-flavor detected and the mean ranks of each taster are shown in Table 1.

The mean rank of each taster's threshold was determined as follows: For each of the off-flavors, each of the 10 tasters was ranked from 1 (lowest estimated threshold) to 10 (highest estimated threshold). If the estimated thresholds of two or more tasters were identical or indistinguishable, these tasters were given equal mean ranks. For example, with tallowy milk 2 tasters in the men's group tied for the lowest threshold, as shown by tasters E and F. In this case their estimated thresholds were lower than 6% concentration; therefore, both received a rank of 1.5 (the mean of 1 and 2). Taster G with a threshold of 6% for tallowy off-flavor received a rank of 3. This same assessment of mean rank is shown in data for the women's group. The estimated threshold for 4 women (H, I, G, A) was at or lower than a concentration of 8% tallowy milk. Each one, therefore, received the mean rank

TABLE 1

Approximate taste thresholds of 10 men and 10 women tasters[1] for selected off-flavors in experimental samples of reconstituted dry milk

Taster	Selected off-flavor								Sum of rank number for each taster	Mean rank for each taster	Number of times taster was among first six	Panel assignment		
	Tallowy		Proteolytic		Storage		Rancid[2]					Accepted		Rejected
	Lowest concentration detected %	Rank of taster	Lowest concentration detected %	Rank of taster	Lowest concentration detected %	Rank of taster	Lowest concentration detected %	Rank of taster				Regular	Alternate	
Men														
F	< 6.0[3]	1.5	< 8.0	1.5	<10.0	4	8.0	4	11	2.8	4	×		
B	12.8	5.5	12.0	4	<10.0	4	< 4.0	1.5	15	3.8	4	×		
C	10.2	4	10.7	3	<10.0	4	10.0	5	16	4.0	4	×		
E	< 6.0	1.5	>16.0	8.5	<10.0	4	< 4.0	1.5	15.5	3.9	3	×		
D	14.9	8	< 8.0	1.5	<10.0	4	4.0	3	16.5	4.1	3	×		
G	6.0	3	13.0	5	<10.0	4	>12.0	9	21.0	5.2	3	×		
I	13.0	7	16.0	6	<10.0	4	12.0	6.5	23.5	5.9	3		×	
H	12.8	5.5	>16.0	8.5	>40.0	9.5	>12.0	9	32.5	8.1	1		×	
J	>16.0	9.5	>16.0	8.5	27.0	8	12.0	6.5	32.5	8.1	1			×
A	>16.0	9.5	>16.0	8.5	>40.0	9.5	>12.0	9	36.5	9.1	0			×
Women														
H	< 8.0	2.5	9.3	3	<10.0	3.5	< 2.0	3	12.0	3.0	4	×		
F	8.0	5	< 8.0	1.5	<10.0	3.5	< 2.0	3	13.0	3.3	4	×		
I	< 8.0	2.5	10.0	4	<10.0	3.5	< 2.0	3	13.0	3.3	4	×		
G	< 8.0	2.5	< 8.0	1.5	<10.0	3.5	6.0	6	13.5	3.4	4	×		
A	< 8.0	2.5	>16.0	8	<10.0	3.5	< 2.0	3	17.0	4.2	4	×		
D	13.0	7	16.0	5	<10.0	3.5	7.3	7	22.5	5.6	2	×		
E	>16.0	9	>16.0	8	>40.0	9	< 2.0	3	29.0	7.2	2		×	
J	9.6	6	>16.0	8	30.0	7	> 8.0	9	30.0	7.5	2		×	
B	>16.0	9	>16.0	8	31.0	8	8.0	8	33.0	8.3	1			×
C	>16.0	9	>16.0	8	>40.0	9	> 8.0	9	35.0	8.8	1			×

[1] Twenty paired comparison tests were used in threshold determinations for each taster.
[2] A higher quality dry whole milk control sample was used for the women's group than for the men's group.
[3] < indicates less than; > indicates greater than.

of 2.5 (mean of 1, 2, 3, 4). Taster F tasted differences at the 8% concentration, and hence received a rank of 5.

The second criterion for selecting members of a panel is a comparison with other tasters in the group. As shown in Table 1, a taster was ranked 4, 3, 2, or 1 according to the number of times he was in the group of the 6 highest ranking tasters. The maximum number of times was 4—representing 4 off-flavors. Such a taster would be more useful on a panel than one who had a low threshold for only one or two off-flavors in milk and was thus ranked 2 or 1.

Two men identified more than 15 out of 20 samples with tallowy off-flavor in the 6% concentration; therefore, their estimated thresholds were less than 6%. Five women detected this off-flavor at the 8% level. The women were not given the 6% concentration. Had they been tested at the 6% level as were the men, it is possible that some of them would have had thresholds for tallowy off-flavor at or below the 6% level.

In tasting for proteolytic off-flavor, 2 persons in each group had a threshold of lower than 8%. Four men and 5 women could not distinguish between the control sample and the sample with 16% proteolytic off-flavor. Their estimated thresholds for proteolytic off-flavor were therefore greater than 16%.

The percentage of storage off-flavor detected by men and women was approximately the same. The high number of persons with thresholds lower than 10% indicates that a lower concentration would have given more information on thresholds for storage flavor.

In tests for rancid flavor, the dry whole milk used as a control for the women's group was superior to that used for the men's group; hence the performance of these 2 groups on rancid flavor should not be compared. The better quality of the control may have made it possible for the women to detect smaller differences than the men between the rancid test samples and the control.

The overall pattern of both groups of tasters is very similar (Figure 2). When the results of threshold tests for the 4 off-flavored milks are combined, considerable range in sensitivity is shown for each group of tasters. Tasters with low mean ranks had low thresholds, and tasters with high mean ranks had high thresholds.

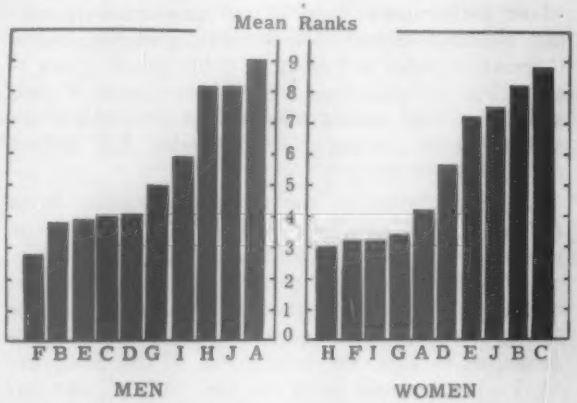

Figure 2. Performance of men and women tasters in threshold tests on various off-flavors in experimental dry milks.

In the threshold test for cooked flavor in evaporated

milk, the performance of the women tasters was determined by sequential analysis. In this procedure the individual's judgments were plotted on a graph which is divided into regions of acceptance, rejection, and indecision (Figure 3). A correct identification is defined as the selection of the sample with evapo-

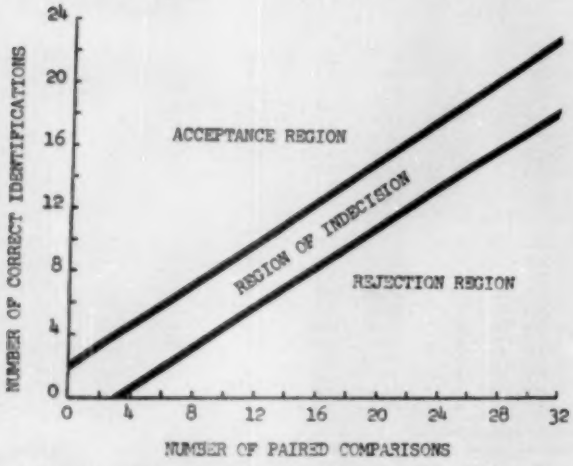

Figure 3. Plan for sequential analysis used in ascertaining the estimated threshold level of a taster.

rated milk as the one which has more cooked flavor than the control sample. The sequence of the correct and incorrect identifications made by a taster is a basic part of this procedure.

The 2 lines indicated in the graph were based on the following considerations: A taster whose performance shows a true proportion of correct identifications of 80% is accepted as a member of the panel. The risk of rejecting such a taster is 5%. A taster whose performance shows a true proportion of correct identifications of 50% is merely guessing, and is therefore rejected as a member of the panel. There is also a 5% risk associated with the acceptance of such a taster. Those tasters who are not accepted or rejected fall in the region of indecision and further testing is needed.

The explanation of the graphic procedure is as follows: Each identification made by a taster is plotted as a point, the coordinates of which are designated as the number of paired comparisons and the number of correct identifications. For example, if a taster correctly identifies the first pair of samples presented to him, the coordinates of the point are (1, 1), i.e., one unit along the base and one unit up; if the identification is incorrect, then the coordinates are (1, 0), i.e., one unit along the base, zero units up. In subsequent paired comparisons, each identification is denoted by a point which is one unit to the right of the preceding point. If the identification is correct the point plotted is also one unit up. Paired comparison tests are continued until one of the following two results is obtained: 1) A plotted point falls on or above the upper line. It is then inferred that the taster is able to detect cooked flavor in the sample containing a certain concentration of evaporated milk. The estimated threshold of the taster is therefore at or below the concentration of evaporated milk tested. 2) A plotted point falls on or below the lower line. It is then inferred that the taster cannot detect the cooked flavor in the sample containing evaporated milk. The estimated threshold of the taster is therefore greater than the concentration of evaporated milk tested.

Results of the tests shown in Figure 4 indicate that 4 of the women, A, I, M, N, identified 10 out of 10 pairs correctly at the 20% and 15% concentrations of evaporated milk. Tasters D, K, and B made more correct selections on the second day of testing than on the first even though a lower concentration of 15% was used. Taster G was accepted at the 20% level on the first trial and also was accepted after 2 trials at the 15% level. The estimated threshold for A, I, M, N,

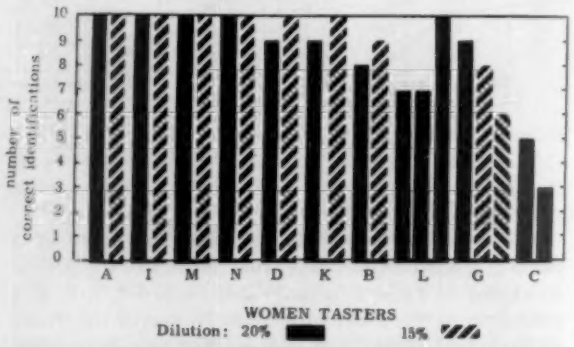

Figure 4. Number of correct identifications for cooked milk flavor in dilutions of evaporated milk paired with fresh milk.

D, K, B, and G was at or below the 15% concentration. Taster L on each of 2 consecutive days made only 7 correct identifications of the sample with the 20% evaporated milk, and as her performance was in the region of indecision each time she was given the 20% concentration on the third day. At that time she correctly identified all 10 pairs and was accepted. More experience with the milk appeared to improve this taster's performance. On the first day taster C made only 5 correct identifications and her performance was in the region of indecision. The results of the 2 days of testing at the 20% concentration placed her responses in the region of rejection.

From these results, tasters A, I, M, N, D, K, B, and G appeared promising as regular panel members. Taster L was considered as a possible substitute.

The performance of 8 tasters in the third threshold test, cooked flavor of evaporated milk in biscuits, is shown in Figure 5. Tasters D, N, and A made 6 or 7 out of 7 possible correct identifications on the first trial and when evaluated by sequential analysis were accepted. Tasters K, M, and L were not accepted on the basis of the first trial but made successively more correct selections on the second or third trials. Tasters

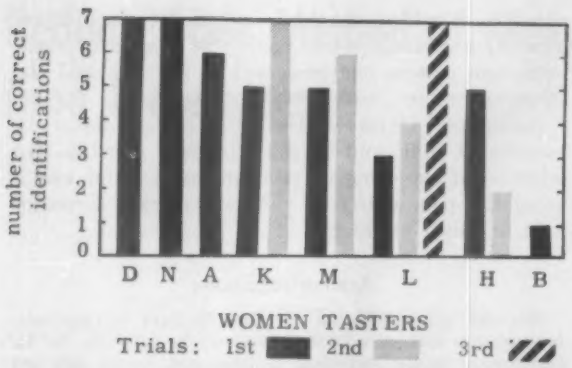

Figure 5. Number of correct identifications for cooked milk flavor in paired samples of biscuits made with evaporated and fresh milk.

K and M were accepted on the second trial. Taster L on the third trial correctly identified 7 pairs and was accepted. It appears that taster L exemplifies the taster whose sensitivity may be increased by experience and greater familiarity with the product. Taster H correctly identified 5 pairs the first day, as did tasters K and M. Taster H, however, made fewer correct selections with a second trial hence was rejected. Taster B made only 1 correct identification out of 7 the first day and was also rejected.

Ranked paired comparison tests of fresh whole milk and the evaporated milks processed by 2 methods, in which both men and women participated, are shown in Table 2. For each pair of samples tasted a rank of 2 was given to the sample selected as having more cooked flavor. A rank of 1 was given to the other sample of the pair.

The significant differences (at the 5% level of significance) among the 5 experimental samples were determined for each taster and for each proposed panel group (regular, or regular and alternates combined). For each taster each experimental sample is represented by a sum of 16 rank numbers (rank of 2 or 1). Two or more of the samples are regarded as being significantly different from each other if the probability that the observed difference between their rank totals exceeds that which would be expected by chance. For example, if no real flavor differences among the samples were present, the expected sum of the rank numbers for each sample would be 24 for each taster.

Data in Table 2 shows that the 6 men tasters selected for the regular panel found significant differences between the evaporated milk processed by high temperature sterilization (Method 1) and that processed by the conventional sterilization process (Method 2). They were, however, unable to distinguish between the fresh whole milk control and the high temperature samples at the levels of concentration used in this study. Men tasters I and H (alternates) and J and A (not assigned to a panel) were unable to find significant differences among any of the samples. The latter 4 tasters also were inconsistent in their ranking of the samples from replication to replication (data not shown). The lack of consistency on the part of tasters I and H, however, was not sufficient to offset the overall results, as the panel of 8 regular and alternate tasters yielded the same results as the panel of the 6 best tasters.

Data on the women's performance show that both the regular panel (the best 6) and the regular panel plus alternates (the best 8) detected significantly (5% level) less cooked flavor in the control sample than in the other 4 samples. They also found no significant differences between the 20% and the 40% dilutions of milks processed by Method 1. They significantly differentiated between the 20% and the 40% dilutions of evaporated milk processed by Method 2 and detected significantly more cooked flavor in the samples processed by Method 2 than by Method 1. Taster D, accepted for the regular panel, was the only

TABLE 2

Taster's performance in ranked paired comparison tests of experimental samples of evaporated milks and fresh whole milk

Assignment	Men tasters	Totals of rank numbers[1] for men tasters					Women tasters	Totals of rank numbers[1] for women tasters				
		Fresh whole milk	Evaporated milks[2]					Fresh whole milk	Evaporated milks[2]			
			Method 1		Method 2				Method 1		Method 2	
			20%	40%	20%	40%			20%	40%	20%	40%
Regular panel	B	20	19	21	28	32	I	16	21	23	28	32
Regular panel	C	19	23	19	29	31	F	16	21	25	26	32
Regular panel	D	20	18	23	30	30	G	17	24	25	22	32
Regular panel	E	22	31	20	26	31	A	17	21	22	29	31
Regular panel	F	23	20	18	28	32	H	18	21	22	28	31
Regular panel	G	19	20	21	28	32	D	19	23	23	24	31
Total		123	130	121	169	188		103	131	140	157	189
Alternates	I	22	22	22	25	29	E	18	22	20	28	32
Alternates	H	21	22	24	25	28	B	18	21	23	27	31
Total, regular panel plus alternates		165	164	167	219	245		139	174	183	212	252
None	J	22	26	25	25	22	J	25	24	25	22	23
None	A	21	21	25	25	28	C	20	25	27	21	27

[1] Based on 16 judgments with rank of 1 indicating the lesser amount of cooked flavor and rank of 2 the greater amount of cooked flavor. Rank numbers underscored by the same line are not significantly different.

[2] Evaporated milk processed by high temperature sterilization (Method 1) and by the conventional process (Method 2).

woman taster who was inconsistent in the ranking of samples from replication to replication. The performance of tasters E and B indicate they would make suitable alternate panel members.

The dilution technique reported here is a method which yields a rapid evaluation of the estimated taste threshold of a potential judge and which can be used for selecting persons suitable for tasting samples of milk or products in which milk is an important ingredient. Examination of the data on the threshold tests revealed that there was no problem of taste fatigue in testing as many as 20 pairs of samples at one session, since the men and women were, for the most part, consistent in their judgments within each session and from session to session. However, such tests as these require a large amount of the test material. In the method requiring 20 pairs of samples at a session, it should be noted that the number of correct identifications made by a taster may fluctuate above and below 15 with increasing concentrations of reconstituted dry milk. In such cases, there are at least two possible threshold values, the choice of which is at the disposal of the experimenter or the statistician. This occurred several times in the tests herein reported.

The sequential analysis procedure developed by Wald *(14)* and applied to sensory taste tests by Bradley *(3)* usually requires a smaller number of samples than the other method used to obtain an estimate of the threshold of a taster. Also, as soon as the plotted sequence of observations falls on or above the upper line or on or below the lower line in Fig. 3 the taster is either accepted or rejected at that particular dilution. However, the sequential procedure involves continual analysis of results which may increase the overall staff time required for threshold tests.

Tests on more off-flavors than the four reported here may be desirable. Persons acutely sensitive to one off-flavor are not necessarily sensitive to all off-flavors. If thresholds of tasters for many off-flavors are known, tasters may be assigned to a panel evaluating the off-flavor for which they have a low threshold.

SUMMARY

Taste thresholds were determined by a dilution technique for 10 men and 10 women for tallowy, proteolytic, storage, and rancid off-flavors in dry milk. The same 20 tasters were tested by a ranked paired comparison method for their ability to discriminate among evaporated milks processed by high temperature sterilization, the conventional sterilization method, and fresh whole milk. By means of these tests, two panels, one composed of six men and the other, six women, were selected.

Additional threshold tests for cooked flavor in evaporated milk and in drop biscuits aided in the selection of the women's panel to be used for evaluating the palatability of different market forms of milk in baked products.

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LITERATURE CITED

1. Boggs, M. M., and Hanson, H. L. Analysis of foods by sensory difference tests. *Advances in Food Research*, 2, 219 (1950).
2. Bohren, R. B., and Jordan, R. A. Technique for detecting flavor changes in stored dried eggs. *Food Research*, 18, 583 (1953).
3. Bradley, R. A. Some statistical methods in taste testing and quality control. *Biometrics*, 9, 23 (1953).
4. Bureau of Human Nutrition and Home Economics. Experimental procedure for conducting taste and smell tests. U. S. Dept. Agr. *Mimeo.*, 8 (1943).
5. Carlin, A. F., Kempthorne, O., and Gordon, J. Some aspects of numerical scoring in subjective evaluation of foods. *Food Research*, 21, 273 (1956).
6. Dawson, E. H., and Harris, B. L. Sensory methods for measuring differences in food quality. U. S. Dept. Agr. *Info. Bull. 54*, 134 (1951).
7. Gilpin, G. L., Dawson, E. H., Toepfer, E. W., and Warren, H. W. Palatability and nutritive value of home-canned chicken. Bureau of Human Nutrition and Home Economics, U. S. Dept. Agr. *Tech. Bull. 1054*, 36 (1952).
8. King, F. B. Obtaining a panel for judging flavor in foods. *Food Research*, 2, 207 (1937).
9. Knowles, D., and Johnson, P. E. A study of the sensitiveness of prospective food judges to the primary tastes. *Food Research*, 6, 207 (1941).
10. Mackey, A. O., and Jones, P. Selection of members of a food tasting panel. Discernment of primary tastes in water solution compared with judging ability for foods. *Food Technol.*, 8, 527 (1954).
11. Peryam, D. R., Josephson, D. V., Remaley, R. J., and Fevold, H. L. New flavor evaluation method. *Food Eng.*, 23, 83 (1951)
12. Schlosberg, H., Pfaffmann, C., Cornsweet, J., and Pierrel, R. Selection and training of panels. *Food Acceptance Testing Methodology — A Symposium*, p. 45. Quartermaster Food and Container Institute for the Armed Forces, Chicago, Illinois. October (1953).
13. Terry, M. E., Bradley, R. A., and Davis, L. L. New designs and techniques for organoleptic testing. *Food Technol.*, 6, 250. (1952).
14. Wald, A. *Sequential Analysis.* 1947. John Wiley and Sons, Inc., New York, N. Y.

Hedonic Scale Method of Measuring Food Preferences

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THE HEDONIC SCALE METHOD has proven to be a very useful tool in food research; however, in no sense is it an "invention" or new discovery. There are only a limited number of basic psychometric methods, and the hedonic scale is no more than a special application of the most generally useful one—the rating scale. It represents a direct approach to the measurement of psychological states.

Background of the hedonic scale method includes the whole history of the development of rating scales, but only a few high-lights can be mentioned. Practical uses of the rating scale date back over 150 years and in those early days included measurement of such things as bath water temperature, wind velocity and other weather phenomena *(3)*. It was therefore on the scene about 70 years before either the rank order or paired comparison methods. The frequency of its use in psychological studies began to increase around the turn of the century. Its development was markedly accelerated after the first World War when psychology began to move out of the classroom and come to grips with practical problems, such as those of education and personnel selection and evaluation. During the last 30 years, and particularly the last 10, the range of psychological applications has increased tremendously and there has been a corresponding increase in the need for psychometric methods. Rating scale methods have been improved through experience and developments in theory. Today they are used extensively in personnel work, consumer research, opinion polling, and in many phases of psychological research.

When were rating scales first used in food evaluation? Scoring and grading systems, which may be considered as forms of the rating scale, were in use by the 1920's *(1)* and may have been applied much earlier. During the past 30 years we have seen many types of rating scales used in food research, technology and quality control.

Essentials of the rating scale method are, first, the definition of a psychological continuum and, second, the establishment of a series of successive categories of response. How good the application is depends upon whether the defined continuum and the categories are meaningful to the test subjects within the context of the problem. The essential features of the hedonic scale are its assumption of a continuum of preference and the direct way it defines the categories of response in terms of *like* and *dislike*.

First work by the Quartermaster Food and Container Institute on this method was done in 1947. A 7-point scale expressed in terms of *like* and *dislike* was used in a survey to determine soldier preferences for menu items. The purpose was to compare this method with the then standard paired comparisons. The rating scale was found to be at least as good and perhaps better. In 1949, when we were seeking a more suitable method to evaluate preference in the laboratory, this idea was re-activated. After a certain amount of preliminary work comparing scale lengths and wording the present form was selected on the basis jointly of reliability and discrimination. Independent experiments had verified the same form as suitable for questionnaire surveying of soldier's food preferences in the field.

The method was first published in 1952 *(5)*, as an initial attempt which could serve as the basis for further development. It was, perhaps, too immediately successful. We tried it not only for laboratory work but also for attitude surveys *(10)* and various other field situations, with generally satisfactory results. Industry and other Government laboratories also began to use it. As a result, the scale has been changed only for special experiments. The Institute is still using the original form for regular work, even though we have known for some time that better forms could be developed for various purposes *(4)*.

The scale is named for the type of response that it seeks to elicit, i.e., one which derives mainly from feeling or affectivity—in general, the emotional aspects of mental life as opposed to the intellectual. Both science and intuition tell us that the most important dimension in this aspect of human experience is the one indicated in the dichotomy, "pleasant-unpleasant." We can conceive of a continuum lying along this dimension on which, theoretically at least, we could place any emotional experience. "Hedonic" is another, though less common, way of referring to this area. Any scale or test which sought to measure on the same continuum could properly be called "hedonic."

Description of the method. Basically, what does one need to know to use the method effectively? What are its major advantages and limitations?

Figure 1 shows the questionnaire currently used

[a] This paper reports research undertaken at the Quartermaster Food and Container Institute for the Armed Forces and has been approved for publication. The views or conclusions contained in this report are those of the authors. They are not to be construed as necessarily reflecting the views or indorsement of the Department of Defense.

[b] Presented at the Seventeenth Annual Meeting of the Institute of Food Technologists, Pittsburgh, Pa., May 16, 1957.

in laboratory preference testing at the Institute. It provides for the rating of up to 4 samples at a session, each one on its separate scale. Presentation is by the single stimulus method, i.e., samples are served individually in succession and each is eaten and rated before the next is served. The test subject is provided with a glass of water and is instructed to "take a drink" during the 40-60 second rest period between samples. Typically, samples are identified by a number or letter code which the subject writes in at the head of the scale.

As for the scale itself, simplicity is its essence; little beyond display is needed to put across the idea. The 9 phrases are arranged along a line, or scale, designed to suggest a single continuum which is emphasized by the successive degrees of affect of the verbal description. The instructions are also designed to suggest the continuum and make the subject's task simple. They are printed separately on cards which are posted in the panel booths and are brought to the attention of new subjects. They read about as follows:

"You will be given several servings of food to eat and you are asked to say about each, how much you *like* or *dislike* it. Use the scales to indicate your attitude by checking at the point which best describes your feeling about the food. Keep in mind that you are the judge. You are the only one who can tell what you like. Nobody knows whether these foods should be considered good, bad, or indifferent. An honest expression of your personal feeling will help us decide. Take a drink of water after you finish each sample and then wait for the next."

Note that the instructions have two functions: first, to describe the mechanism of the test; second, to encourage freedom of response. The intent is to have the subject answer on the basis of his first impression and to minimize the intellectual approach, i.e., one involving conscious reasoning and judgment, though, of course, these cannot be entirely avoided. The hedonic scale method is predicated on the belief that direct responses, which we may assume are based to a considerable extent on feelings, are more valid for predicting actual behavior toward food than are responses which depend more on reasoning. Both scale and instructions are designed for use with subjects who are entirely without experience in food testing. The "naive" subject responds quite adequately; on the other hand there is no evidence that this simplicity makes the method any less effective with more sophisticated subjects.

The specific way in which the scale, or scales, are presented on the questionnaire, i.e., long or short lines, vertical or horizontal orientation, or whether it begins with *like* or *dislike*, does not appear to be critical. A number of variations have been used with apparently no major effect on the results. They are used not only in the laboratory but also for the preference testing of foods by soldiers in field situations, e.g., when foods are served as a part of a regular meal.

Figure 2 shows the hedonic scale in a different context. This form is employed in questionnaire studies of food preferences and attitudes *(10)*. In the laboratory tests a person is given actual food samples to eat. Hence the sensory components of his experience, based upon the flavor of the specific samples, will be very important. Consequently, he can consider only a few foods at one time. However, we must recognize that his response is determined, in part, by his general attitude toward the food type based on his prior experiences with it. The food preference survey is designed to explore this area. Here the stimuli are not actual food samples, but simply food names. A questionnaire can include up to about 60 items without any evidence that people begin to answer carelessly. Much of the following discussion will apply to both survey and laboratory preference data; however, each has its own special problems of analysis and interpretation. Our primary interests here will be with the sensory test data

PREFERENCE

Name		Division	Date

Code	Code	Code	Code
Like Extremely	Like Extremely	Like Extremely	Like Extremely
Like Very Much	Like Very Much	Like Very Much	Like Very Much
Like Moderately	Like Moderately	Like Moderately	Like Moderately
Like Slightly	Like Slightly	Like Slightly	Like Slightly
Neither Like Nor Dislike	Neither Like Nor Dislike	Neither Like Nor Dislike	Neither Like Nor Dislike
Dislike Slightly	Dislike Slightly	Dislike Slightly	Dislike Slightly
Dislike Moderately	Dislike Moderately	Dislike Moderately	Dislike Moderately
Dislike Very Much	Dislike Very Much	Dislike Very Much	Dislike Very Much
Dislike Extremely	Dislike Extremely	Dislike Extremely	Dislike Extremely
Comments:	Comments:	Comments:	Comments:

Figure 1. Hedonic scale form used for laboratory preference tests.

Not Tried	Stewed Tomatoes	Like Extremely	Like Very Much	Like Moder-ately	Like Slightly	Neither Like nor Dislike	Dislike Slightly	Dislike Moder-ately	Dislike Very Much	Dislike Extremely
Not Tried	Hot Cornbread	Like Extremely	Like Very Much	Like Moder-ately	Like Slightly	Neither Like nor Dislike	Dislike Slightly	Dislike Moder-ately	Dislike Very Much	Dislike Extremely
Not Tried	Pot Roast of Beef	Like Extremely	Like Very Much	Like Moder-ately	Like Slightly	Neither Like nor Dislike	Dislike Slightly	Dislike Moder-ately	Dislike Very Much	Dislike Extremely
Not Tried	Fresh Milk	Like Extremely	Like Very Much	Like Moder-ately	Like Slightly	Neither Like nor Dislike	Dislike Slightly	Dislike Moder-ately	Dislike Very Much	Dislike Extremely
Not Tried	Hot Tea	Like Extremely	Like Very Much	Like Moder-ately	Like Slightly	Neither Like nor Dislike	Dislike Slightly	Dislike Moder-ately	Dislike Very Much	Dislike Extremely
Not Tried	Tomato Noodle Soup	Like Extremely	Like Very Much	Like Moder-ately	Like Slightly	Neither Like nor Dislike	Dislike Slightly	Dislike Moder-ately	Dislike Very Much	Dislike Extremely
Not Tried	Chicken Rice Soup	Like Extremely	Like Very Much	Like Moder-ately	Like Slightly	Neither Like nor Dislike	Dislike Slightly	Dislike Moder-ately	Dislike Very Dislike	Dislike Extremely
Not Tried	White Bread	Like Extremely	Like Very Much	Like Moder-ately	Like Slightly	Neither Like nor Dislike	Dislike Slightly	Dislike Moder-ately	Very Much Dislike	Dislike Extremely
Not Tried	Vegetable Soup	Like Extremely	Like Very Much	Like Moder-ately	Like Slightly	Neither Like nor Dislike	Dislike Slightly	Dislike Moder-ately	Very Much	Dislike Extremely

Figure 2. Hedonic scale form used in questionnaire surveys.

with occasional references to that from the attitude surveys.

Analysis of the data. The potential of the method can only be realized through appropriate analysis of the data. In most instances this implies that a well-planned design must be set down before the study begins.

Scale responses can be treated either as categorical, discrete data or they can be considered as points on a continuum so that the statistics of variables applies. Analysis as discrete data is insensitive compared to the other approach and is used only in special cases. Therefore, only the second approach will be considered here. One limitation that must be recognized in applying the ordinary statistics of variables is that the scale categories are known to be of unequal width psychologically; therefore, some of the assumptions are not justified. In practice, however, we assign successive integers to the categories and analyse as though they were equal without running into any major trouble. It has been shown that the results are quite similar whether one uses integers or the true scale values. This means that all of the modern statistical techniques can be applied.

Most food technology problems are concerned with differences among treatments of the same food. In experiments using the hedonic scale, the treatments may represent either discrete or continuous variables, and there may be more than one variable in a study. The usual statistical tests can be used, such as the *t* test for the difference between two means or the Duncan test *(2)* for differences within a group of means. Variance analysis is appropriate in any case, and is necessary to achieve maximum sensitivity, but, in complex studies, it must be coupled with careful experimental design to give maximum efficiency. Factorial designs are to be recommended in multi-variate problems. For variables involving more than 2 levels, the levels should be distributed equally in terms of some mathematical function. This permits analysis using orthogonal polynomials or curve fitting so that the shape of the curve can be specified and the optimum located. Use of such experimental designs greatly increases the sensitivity of the tests, or alternately, reduces the labor necessary to obtain a definitive answer.

When the question is one of the relationship of preference to a physical or chemical measure—or any other measure such as cost or volume of sales—correlation and regression analysis are applicable.

Reliability. The reliability of a method may be considered in different ways. First is the question of reproducibility of the results when all conditions have remained constant — test-retest reliability. In this sense the hedonic scale is adequate. Good reproducibility, well within statistically estimated limits, is usually found when the same food items have been tested repeatedly under the same conditions. However, another order of reliability is sometimes important to the user of the results, who would like to have a test which gives the same results time after time and regardless of conditions, for example, to have the average rating for a given food vary only within a small range no matter where, how, or by whom it was tested. Considering the many factors which may affect the individual ratings, this is probably too much to expect.

The average rating for a food is affected by 3 sources of variation. Each of these sources may or may not be of concern, depending on the purpose

of the experiment. In variance analylsis terms, the first kind of variation is the judge-treatment interaction. This is a measure of the disagreement among people as to which treatment is preferred over another and by how much. Such variation is always present, even when the same subjects rate all treatments at the same session, which is the situation for the majority of food technology problems where one is concerned with differences due to processing of raw materials. This variation is minimal; differences in means of 0.4 to 0.5 of a scale point are usually significant when 30 to 40 subjects are used. Also, the relative preferencees established in such a test tend to be stable.

The second kind of variation is that due to sampling errors among subjects drawn from the same population. It results both from individual differences in liking for foods and from differences in the way people express themselves. Some are enthusiastic, others restrained; within a given group there may be people who tend to use the low end, others the high end, and still others the middle of the scale. Such variation becomes important when all samples cannot be tested at the same time, and by the same people, as in a storage study.

In this case judge variation must be used as the error term, and the test is usually less sensitive to differences than when the treatments are rated by the same subject. From 0.8 to 1.0 scale point difference between means is usually required for significance at the 5% level. This variation can be called a "session" effect. It is also important when there are more treatments than can be tested by one subject. However, in the latter case, the effect can often be confounded, by proper experimental design, with effects that are of little importance.

The third kind of variation can also be called a session or group effect, but is of a different order and will be added to variation from the other sources. It arises when samples are tested under different environmental conditions, in different test situations, or by different populations. Variation of this kind can be much larger than that from the other sources. It causes differences in the level of rating—e.g., the same people will rate hot soups higher in the winter than in summer and soldiers in the field tend to rate certain canned meats lower than do laboratory panels. It may cause differences in relative preference—e.g., of 2 formulations of chili, people from one population may prefer the spicy and people from another population, the bland. The level of rating seems to be affected more often than the relative order of preference. In one experiment comparing laboratory ratings for 12 ration items with ratings obtained from groups of soldiers in the field, the soldier's average rating was 0.8 of a scale point lower and they showed a 1.0 scale point greater range between items; however, the correlation between the two groups was +.92 *(6)*.

This third kind of variation cannot be considered in assessing test reliability. The fact that the scale will reflect differences in environment, test conditions, or populations does not mean that it is unreliable, but simply shows that it is sensitive. Real changes in preference are being measured. Other types of tests, such as rank order or paired comparisons, do not pick up these changes in preference level. They provide for comparison only among samples that are simultaneously present; hence they give only relative preference.

Essentials of the method. Certain essentials of the hedonic scale method, such as the single stimulus method of presentation, the establishment of a well-defined continuum, and the selection of phrases to make the intervals as clearly successive as possible, are standard features of the rating scale methods. The real contribution of the hedonic scale method lies in application of these principles to the problem of measuring food preferences. Briefly summarized, the essential features of successful application are: (a) definition of the continuum as one of affectivity, rather than judgment, (b) structuring the scale with *like* and *dislike* terms, which are easily understood and meaningful, and (c) the policy of not "tampering" with the subjects but encouraging free, uninhibited expression. Other characteristics of the scale are not considered essential to the method. The number of scale categories may be changed without basically changing its function. Research at the University of Chicago *(4)* has shown improved discrimination up to 9 categories, with some indication that a larger number might be even more effective. It is not critical to have the category descriptions exactly as in the present form. They must, of course, clearly indicate the affective continuum and encourage its use, but this might be done as well with other words. Further, some phrases and series of phrases are more effective than others in getting across the idea of the successive nature of the scale intervals. Ambiguous phrases and words must be avoided. The present scale appears adequate in this regard with the exception of the phrase *dislike moderately,* which different people seem to understand differently. Apparently the scale would discriminate better if a less ambiguous phrase could be substituted for this one Another feature shown to be non-essential is the inclusion of the *neither like nor dislike* category. Its removal would do no harm and might even improve discrimination. It was also indicated that the scale need not be balanced, i.e., it does not have to have an equal number of *like* and *dislike* categories.

Interpretation. There are a number of problems involved in the interpretation and use of hedonic scale data. When a food technologist runs a test he does it to find out something about the foods—their characteristics, their probable acceptance by consumers, etc. With his attention thus oriented, he may lose sight of a very pertinent fact. The hedonic scale is designed to measure human behavior potential, not characteristics of food. Foods are evaluated indirectly by making inferences from the behavioral measures. The foods themselves constitute only one of the factors which are contributing to the final test results. Potentially a person may respond to his whole environment, both external and internal. Any aspect of it may control his behavior to some degree

at any given moment, and we cannot always predict what part is going to exert the strongest control. In a food preference test, we are sure that the food samples, which may be held constant for all subjects and for all successive tests, are a very important aspect of the environment. But peoples' responses will also be affected by personality, long and short range attitudes, physical well-being, and other physiological and psychological variables *(7)*. Thus, we should expect a test to be sensitive to changes in many factors to a greater or lesser degree.

Special effects. Several effects which appear in hedonic scale tests have been frequently confirmed and need constantly to be considered in test procedure. They are all concerned with inter-effects among samples when more than one is presented in the same test session.

The first is the so-called "contrast" effect, where an average quality sample will tend to rate low when preceded by a good quality sample of the same type and to rate high when preceded by a poor quality sample. This is seen as a logical result when we consider that the first sample, because of its recency and vividness, becomes an important part of the total frame of reference in which the subject responds to the second. This effect is not observed, or is noted less often, when 2 foods of different kinds are presented. Just to assure that we do not try to make "contrast" into an eternal principle we should note a contradictory effect which appears occasionally. We might call it "contamination" effect. Here the rating for an average quality sample will tend to move in the same direction as those with which it appears. This has been noted in storage studies where the rating of a constant quality control has progressed steadily downward from one storage period to the next as the stored samples deteriorated. Psychology might consider this as a special case of stimulus generalization; the presence of a number of poor quality samples in the series develops a low-preference attitude which affects the better quality sample.

A third effect can be called "position" effect. The first sample presented occupies the best position, preference-wise, and the later samples tend to be rated lower. This effect appears so frequently that it must always be anticipated. However, it varies considerably among foods both as to degree and where in the series it first appears. With some foods, e.g. coffee, the drop in preference occurs after the first sample and is rather large. With others it may be only slight or may not appear at all up to the third or fourth sample. Sometimes, e.g., in testing fresh milk or orange juice, it may be entirely absent. This effect can be balanced out by using all possible orders of presentation of samples an equal number of times.

Applications. The hedonic scale method is flexible. Its use seems feasible in a broad range of situations and with any problem where we might want to evaluate on the criterion of human preference. It has been used most often in laboratory studies where the objective is to obtain information about probable acceptance as a guide to further development work. Since, as with other methods, relative preference is assessed most accurately and reliably, it has its greatest value when treatments can be compared in the same session. It is used constantly in the Quartermaster Food and Container Institute laboratory to determine the effects of variables such as processing, formulation, raw materials, packaging, and storage conditions. The method is also employed in problems where one must rely on the constancy of the absolute level of rating, such as evaluating the effects of storage over a period of time, although here the error is larger, and conclusions are not so reliable. The absolute level of rating also serves as a preliminary estimate of field acceptance.

Evaluation of food quality, as by a trained panel of product specialists, is often considered as different from consumer preference evaluation. It is assumed that trained panels use derived criteria which are somehow different and perhaps more stable than those employed by the ordinary consumer. However, our experience has been that a trained panel is just another sampling of consumers expressing their preferences. They will give the same results, within experimental error, using the hedonic scale as with any of the special methods which depend upon judgments of quality.

Suitablilty of the hedonic scale method in a wide range of situations and with many different populations of test subjects derives from its simplicity. The subjective continuum on which it measures is a universally meaningful one and the language it employs is easily understood.

Validity. Test construction doctrine requires consideration of test validity, something which is often neglected in food technology where we are usually satisfied merely to achieve reliability. However, let us assess the validity of the method under discussion by trying to answer the question, "How well does it measure what it is supposed to measure?" First we must decide what it is supposed to measure. A test may be valid, of course, for one purpose and entirely invalid for another.

It is often assumed that the hedonic scale measures acceptance. For example, the statement, "Food *x* scored over 5.0 and is therefore acceptable," not only makes this assumption but further assumes that there is a direct, known relationship between scale values and acceptance. Such over-simplification serves no useful purpose, and does harm in diverting one from the attempt at meaningful interpretation. But what does the scale measure? The best answer is that it measures something which we call "preference," which is a short-hand method of referring to the hedonic continuum. Preference is measured for the purpose of predicting acceptance, which is tantamount to establishing acceptance as the major validating criterion. Now, how does one define and quantify acceptance? It is not on an all-or-none-phenomenon—you cannot say that people either *do* or *do not* accept a food. There are degrees of acceptance. Some objective indices of acceptance that have been used, or suggested, are amount of food con-

sumed, frequency of choice of a food among competitive foods, and, in the market scene, frequency of purchase. One definition of acceptance combines the objective and subjective and affirms that we should consider it as "consumption with pleasure" *(7)*. Most of us would intuitively agree that the ingestion of food serves a broader purpose than simply nourishing the body.

Let us, then, accept both the measurement of preference and the prediction of acceptance as the objectives of hedonic scale measurement. How well does it do either? To get an objective validating criterion for measurements on the affective continuum is difficult but not impossible. Physiological and behavioral indicators might be found; however, the experience has been that such measures are less precise and reliable than are people's verbal statements. Further, their theoretical justification is no better—if as good. Essentially, then, we must rely on the face validity of the hedonic scale as a good measure of preference. We accept it because it obviously is measuring what it is supposed to measure, and because there is no better measure against which to check it.

This same argument applies to the "pleasure" part of the "consumption with pleasure" definition of acceptance. However, we may still ask about the prediction of consumption or choice. We know that many things, in addition to preference as measured in any test situation, will affect choice and consumption. Some of the major influences are ideas about health and nutrition, cost, the need for calories as affected by climate, activity, and other factors, and the availability of competitive foods. Data are available from studies conducted by the Quartermaster Food and Container Institute which show that preference is very important in spite of the many other factors that must be considered. In an extensive experiment involving the feeding of 100 soldiers over a one-month period in a special mess-hall situation where they had considerable freedom of choice in regard to the foods they could select, it was shown that preference ratings obtained by the questionnaire method correlated about +.74 with both the frequency of item selection and the amount consumed *(9)*. Other investigations where consumption or frequency of rejection were correlated with preference ratings have given comparable results. Depending on conditions and type of food the correlations have varied between +.30 and +.87. We may conclude that, generally, over half of the variation in these objective indices is explainable on the basis of preference.

Conclusions

The most serious limitations of the hedonic scale method are those which apply equally to any measurement of preference under restricted conditions, such as inadequacy of the sampling of test subjects, the possibility of bias, and the fact that tests are run under only a limited range of conditions which may or may not be appropriate. Certain other limitations are inherent in the rating scale method, such as its susceptibility to the various "effects," rather high variability in the data, inequality of scale intervals, and the lack of a zero point. In deference to those whose expectations are highly optimistic, it is noted that values on the scale cannot validly be interpreted in terms of objective food acceptance behavior except within a wide range of error. However, in general these are limitations only when physical measurement is used as the standard of comparison. Whether or not there are limitations in comparison with other methods of measuring preference is still being debated. The suggestion has been made that it does not discriminate as finely between samples as paired comparisons. This has been disproven for foods in the average preference range (8); however, the possibility that paired comparison does discriminate better with well-liked foods is still open.

Major advantages of the method are:

(a) its simplicity which makes it suitable for use with a wide range of populations, (b) subjects can respond meaningfully without previous experience, (c) the data can be handled by the statistics of variables—an advantage inherent in rating scale data, and (d) in contrast to other methods, within broad limits the results are meaningful for indicating general levels of preference.

LITERATURE CITED

1. Boggs, M. M. and Hanson, H. L., Analysis of foods by sensory difference tests. In *Advances in Food Research*, Vol. II, Academic Press, Inc. New York, 1949.
2. Duncan, D. B. Multiple range and multiple *F* tests. *Biometrics*, **2**, 1-42, 1955.
3. Guilford, J. P. *Psychometric Methods*. McGraw-Hill, New York, 2nd ed., 1954.
4. Jones, L. V., Peryam, D. R., and Thurstone, L. L. Development of a scale for measuring soldiers' food preferences. *Food Research*, **20**, 512-520, 1955.
5. Peryam, D. R. and Girardot, N. F. Advanced taste test method. *Food Eng.* **24**(7), 58-61, 194 (1952).
6. Peryam, D. R. and Haynes, J. G. Prediction of soldiers' food preferences by laboratory methods. J. Applied *Psychol.*, **41**, 2-6, 1957.
7. Pilgrim, F. J. The components of food acceptance and their measurement. *Am. J. Clin. Nutr.*, **5**, 171-175, 1957.
8. Pilgrim, F. J. and Wood, K. R. Comparative sensitivity of rating scale and paired comparison methods for measuring consumer preference. *Food Technol.*, **9**, 385-387, 1955.
9. Schutz, H. G. Preference ratings as predictors of food consumption. *Am. Psychologist*, **12**, 380, 1957.
10. Wood, K. R. and Peryam, D. R. Preliminary analysis of five Army food preference surveys. *Food Technol.*, **7**, 248-249, 1953.

Methods for Rating Quality and Intensity of the Psychological Properties of Foods

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THE PONDEROUS TITLE of this paper suggests that only a two volume handbook could do justice to the subject matter it defines. Actually, several large texts have been devoted entirely to the first part of the title, namely, to the methods for rating quality and intensity of psychological attributes *(8, 14, 17)*. On the other hand, when the last word, "foods," is added, we can readily summarize the entire subject in a word or two: "use panel methods." More completely, and employing one long sentence, our summary would read: "In order effectively to rate the perceived qualities and intensities of foods, you should select the most appropriate psychological (psychometric) method for your purpose and administer it to a suitable panel of people, all the while exercising control in the testing process and in the interpretation of the findings."

Food technologists these days are publishing more papers on human ratings of foods than are psychologists. One reason is that there are more food technologists than psychologists professionally concerned with consumer properties of foods. In addition, the food technologist has learned that a panel judgment is the most valid way of evaluating his products. Further, he has learned that human subjects can identify and reject foods by criteria which escape physical, chemical, or bacteriological methods. The preponderance of activity by food technologists does not suggest that psychologists are not contributing to advances in panel methodology. In fact, Jones, Bock and Thurstone of the Psychometric Laboratory at the University of Chicago *(7)*; Schlossberg and Pfaffman at Brown *(7)*; Siegel of Alabama; Beebe-Center at Harvard *(2)*, and Peryam, Pilgrim and Schutz at the Quartermaster Laboratories, are representative of contemporary psychologists working specifically with measurement of reactions to foods. It may be of interest to note that the late Professor Thurstone was honored for his fundamental contributions to the basic psychophysical methods upon which all of us depend. Although much later in time, his efforts are viewed as pioneering in the same light as such 19th Century psychophysicists as Fechner, Weber, Thorndike and Urban *(1, 8)*.

If you wonder why so much stress is placed on psychology, we should explain that just as engineering and other technologies depend upon the root sciences of mathematics, physics, chemistry or biology for the principles and methods with which to work, so too does the food technologist in his panel activity depend upon psychology. Already some food technologists are studying psychometric methods so that they can apply them more effectively. They recognize psychology as the root science of human behavior, from which the principles of panel applications are defined.

Later on, we shall review some of the psychophysical and special rating methods, but first let us ask what one might learn from a scaling approach to foods and see if we can arrive at any useful generalizations.

In broadest terms, the problem of the panel and of the individual panel member as well, is to define the stimulus, and for present purposes the stimulus is a food or beverage. This same objective is identical with that of all psychology, according to S. S. Stevens *(14)*. He reasons that the complete definition of the stimulus involves a specification of all the transformations of the environment, both external and internal, which leave the response invariant. The problem of complete stimulus definition, when converted to food terms, could be paraphrased as follows: *A panel test of a food is complete to the extent that it succeeds in defining consumer reaction to the food under study.*

The essence of the psychophysical relationship is the change in response which accompanies a change in the stimulus.

In other words, the consumer reaction is never just an isolated subjective datum. Each response is related to stimulus properties which can be measured along the lines illustrated in Table 1. Although the list is far from complete, it indicates the relation between the stimulus (affecting the receptor systems) and the resulting response parameters. It is apparent that if the stimulus has been completely defined in physical-chemical terms, the response will be more predictable than if it is incompletely defined. Absolute prediction is not yet possible because we do not yet have sufficiently accurate and precise measures of the physical or objective correlates involved. In some instances, as in the case of odor, we do not yet know which stimulus properties are related and which are unrelated to response. For example, the color

TABLE 1
Examples of the interaction of physical properties with sense systems to produce measurable human reactions to foodstuffs

Stimulus property (physical)	Sense system (physiological)	Consumer reaction (psychological)
Reflects radiant energy	Vision	Color, texture, shape, size, cleanliness
Temperature	Warm, cold	hot—cold
Viscosity	Kinesthesis and pressure	Thick, thin
Density	Pressure and kinesthesis	Heavy, light
Shear strength	Pressure, kinesthesis	Tough, stiff, soft
Moisture content	Pressure, cold	Dry—wet
Vapor pressure	Olfaction	Odor
Solubility	Gustation	Taste
Surface contour	Pressure, pain	Rough, prickly
pH	Gustation, pain	Sharp, sour

of a food can be rather well predicted from spectrophotometric data, but we have as yet devised no instrumental reading which will correlate with *burnt, nutty, fishy,* or other odor qualities. As a consequence, we must depend upon psychological measures of quality and intensity.

It is indeed encouraging that all the attributes of our responses yield to scaling or measurement, which in turn provides the useful possibility of prediction. In other words, if a significant number of panel members note the presence of a salty taste and a woody odor in a sample of fresh milk, it is safe to conclude that something has been added. Often in such instances it is essential that we learn how much of a change is present. Various approaches are widely used for measuring the extent of taste and odor change; e.g., triangle, duo, trio, and other "difference" approaches. Quantitative tests of this type are special forms of psychophysical methods involving threshold measures.

Figure 1 illustrates the classical measures of threshold in the stimulus continuum. It will be noticed that the two ends of the response continuum are bounded by the absolute and terminal thresholds. The three difference thresholds (DL's) show that rather than attaching to the arithmetic value of the stimulus, they are a constant fraction according to Weber's Law. Let us illustrate. The difference between .06% and .07% NaCl in milk would be quite noticeable, but at higher NaCl concentrations, the same increment of 1/6% would be required before the change would be noticed; namely from 3% to 3.5%, and at 6%, one full percentage would be required before a change is perceptible. Incidentally, the quantal unit of just perceptible change has been termed a "just noticeable difference" (jnd), and it is a useful unit for describing degrees of difference. Weber's Law states that "in comparing magnitudes it is not the arithmetical difference, but the ratio of the magnitudes which we perceive." It was applied by Fechner, who learned that the response is proportional to the logarithm of the stimulus. This relation is called Fechner's Law *(3)*.

Both of these expressions are well described in reference texts by Woodworth *(17, 18)*, Andrews *(1)* and Guilford *(8)*, and will not be discussed here. Incidentally, anyone who is responsible for the administration of panel tests will find J. P. Guilford's book entitled *Psychometric Methods*, a clearly written and helpful "how to" book. His discussions of the major methods of psychophysics — especially average error, minimal changes, and the constant methods — along with the psychological scaling methods — pair comparisons, ranking, rating scales, equal appearing intervals and their variations — are most valuable.

Although many of the psychophysical methods were developed and widely applied in the 19th Century, their uses, limitations, and values are perhaps not well known to those of us in the food field — who could make most use of them. In the interest of clarity, let us review a few definitions of terms already mentioned: A *stimulus* is defined as any change in external energy that activates a sense organ and its

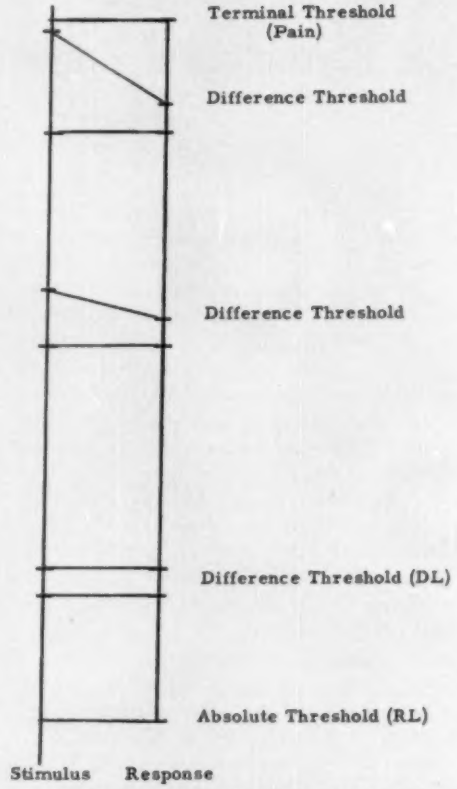

Figure 1. Measures of threshold in the stimulus continuum.

receptors. A *threshold* is a computed stimulus value marking a point on a continuum above which a response is reliably elicited and below which a response is uncertain. A *continuum* refers to a property of the various stimulus dimensions in terms of which stimuli may be ordered.

In addition to threshold and difference measures, other psychophysical measures of intensity have been worked out. They are summarized with illustrations in Table 2. A given method may have two or more names, depending upon the preferences of the writer. We have attempted to use the most common name for each so that the deeply interested worker may most readily find them in the most convenient reference work. It will be noted that in the literature great emphasis is placed on the method and the mathematics involved in the interpretation of results. This emphasis is traditional for the reason that responses are variable from time to time, from stimulus to stimulus, and from person to person. This variability has led to the development of special techniques, correction or weighting factors, and finally, statistical buttresses have been built to protect us against the escape of elusive data *(5)*.

Some of the methods listed in Table 2 involve comparative judgments; some can be effected by single stimuli techniques or the so-called absolute methods. The mathematics which one can validly apply to some of the methods differ widely from the other types.

With method evaluation in mind, let us review the basic classes of scales to see if the way that the

TABLE 2

Determination	Problem	Methods	Application
Absolute thresholds	What is the smallest stimulus that will give rise to a response?	Minimal changes, constant methods	What is the least concentration of an impurity which can be detected in milk or in chocolate?
Differential thresholds	What is the smallest detectable change in a stimulus?	Average error, minimal changes, constant methods, triangle	What decrease in salt level in tomato juice is noticeable?
Equality	What values of 2 or more different stimuli produce the same response or appear equal on the same scale?	Minimal changes, average error, constant methods, triangle, duo-trio	What quantity of Spice "A" will appear as intense as a given amount of Spice "B"?
Order	In what order from least to greatest should a set of stimuli be placed?	Rank order, pair comparisons, rating, ratio, judgment	Rank in order the redness of 7 varieties of strawberries
Equality of intervals	Where is the difference between 2 experiences equal to the difference between 2 other experiences?	Equal sense distances, equal appearing intervals, rank order	Does the canning of peas produce a flavor quality midway between those of freezing and drying?
Equality of ratios	What stimuli produce sensations having a given ratio with respect to each other?	Scaling methods, successive intervals	What hop level will make one beer twice as bitter as another?
Stimulus rating	How accurately can one estimate the correct physical value of a stimulus?	Many of the above and variations of them — especially successive intervals	What cooking temperature produced each of 4 pie crust colors?

reactions can be combined is similar. Table 3 groups the types of operations and averaging measures that may be used when one employs a most primitive scale, such as the *nominal,* or more advanced scalar approach, such the *ratio scale.* The empirical operations define the type so that one can decide which type of averaging is permissible.

The nominal scale, by way of example, results in an operation such as numbering or lettering laboratory beakers, a panel task in which the instruction is given simply to place similar odors together into the fewest groups possible. An ordinal scale would result from a panel ranking of five beverages as to the intensity of sweet taste.

The *interval scale* is represented by temperature scales, calendar dates, or calibrated hedonic scales. Examples of ratio scales are those of length, weight, loudness or electrical resistance. The difference in the last two types is that the ratio scales have a null point "built in" while the interval scales do not. Most scaling efforts fit on the first two types.

Table 3 is intended only as a condensed guide for easy reference and space will not permit any fuller discussion of it *(15).*

The scaling or rating methods are in general much more popular than are the psychophysical methods. The ease with which they can be given and understood contribute to their appeal; it will be noted that in contrast to the psychophysical methods, there is usually no physical scale on which the stimuli can be calibrated.

In order to compare the two, perhaps it would be valid to note that the psychophysical methods are devoted largely to the intensitive or quantitative aspects of experience, while the rating approaches provide more freedom for qualitative choice. With this latter category, variations on old themes or new methods are expected as the qualities under investigation vary. With ratings, however, we usually have only nominal or ordinal ordering and therefore, must restrict our interpretations. In some cases, nevertheless, the nature and form of the distribution of responses is known and measurement is the product.

On ratio or interval scales, the equivalence of units, or the linearity of the scale is usually known. We would aspire ultimately to converting our rating approaches to these classes, since they have the characteristics we usually ascribe to physical measures.

In a previous paper we grouped panel activity into difference, preference and analytical categories *(6).* The threshold technique is usually a difference method, resting upon probability of response. The preference rating methods have been adequately treated elsewhere *(11),* leaving us to review only the rating of quality for analytical purposes.

We referred to the methods of pair comparison; rank order; equal appearing intervals; successive categories; and finally, we will treat the numerical, graphic, standard, cumulated points and forced choice rating methods.

The advantages of rating methods are listed by Guilford *(8)*:

1. Ratings require much less time than either pair comparisons or ranking methods.
2. The procedure is far more interesting to the observers, especially if graphic methods are employed.
3. Rating-scale methods have a much wider range of application.
4. They can be used with psychologically naive raters who have had a minimum of training.
5. They can be used with large numbers of stimuli. Even the method of ranking becomes difficult and

TABLE 3

Scale	Empirical operations	Permissible transformations	Permissible measures of central tendency and dispersion
Nominal	Determination of equality	Any one-to-one substitution	Mode
Ordinal	Determination of greater or less	Any increasing monotonic transform	Median, percentiles
Interval	Determination of the equality of intervals or of differences	Multiplication by and addition of a constant	Arithmetic mean
Ratio	Determination of the equality of ratios	Multiplication by a constant (after Stevens)	Geometric and harmonic mean, coefficient of variation

irksome when there are more than 30 to 40 stimuli.

6. Some investigators in experimental aesthetics maintain that the best judgments are made when stimuli are presented singly, that comparative judgments destroy the aesthetic attitude.

TYPES OF RATING SCALES

The five principal types of rating scales outlined in Table 4 are briefly summarized below:

1. **Numerical scales.** Numerical scales may be unipolar or bipolar in form, or may follow any or all of the modifications of scale structure suggested by Table 3. The effectiveness of a numerical scale depends primarily upon the extent to which the scale items apply to the quality or trait being judged. When words are used, the objectivity, clarity, precision and distinctiveness of scale items will vary with the nature of the qualities present and those being rated. Without careful development, numerical rating scales are subject to many of the errors and limitations mentioned previously, but for many applications, they are completely adequate.

2. **Graphic scales.** The graphic scale is the most popular and widely used type of rating scale. The lines of the graphic scale may be continuous or broken and run in either a horizontal or vertical direction. Several objects can be rated at once on one quality at a time, tending to counteract the "halo effect." This arrangement also permits a more extensive definition of the quality and the steps on the scale. Some basic principles of graphic scale development have been recommended: 1) Rate one quality on each page; 2) make scale lines at least 5 inches long; 3) plan for a continuous, rather than a broken scale line, and 4) have all the "good" or "high" ends in the same direction. The merits of graphic rating scales outweigh their disadvantages, though they are subject to the same general limitations as are other rating scales.

3. **Standard scales.** Standard scales derive their name from the fact that they present to the rater a set of standards that have been previously calibrated by some scaling method such as equal appearing intervals or pair comparison. Examples of this technique are photographs of specimens for judging texture and color of vegetables. The standards are designed to correct the differences of a shifting scale and unequal intervals in rating, by providing a permanent "yardstick," rather than a set of abstract numbers as the criteria for judgment. In actual practice, however, it has been found that because of the difficulty and expense involved, standards are often crudely made and that consistent, uniform ratings are the exception, rather than the rule.

4. **Rating by cumulated points.** Rating by cumulated points involves a unique method of scoring, in which the score is an average or sum of a number of points weighted or unweighted. Contrasting examples of this method are the *check-list* method, the *guess who* techniques and the scaled check-list. The check-list method is especially useful in breaking down and assigning quantitative scores to a number of components of a complex judgmental situation. Scores for the various components are weighted according to their relative importance and the score is the algebraic sum of the weighed sub-scores. In the *guess who* technique, the rater is given a quality or factor and instructed to match the object to the quality, which is a direct reversal of the usual rating method. Insufficient data are available to make a comparative evaluation of the relative efficiencies of the two techniques. The scaled check-list is similar to the *guess who* method, except that the items have been weighted by their scale value. After selecting a group of positive and negative items applicable to the subject of judgment, the score is found by calculating the mean difference of the scale values of the positive and negative items. There is no assumption of a psychological continuum among the scale items, which calls into question the validity of averaging the scale values as a method of scoring.

Check-list instruments are simple and easy to use and their chief value lies in their facility for assigning quantitative scores to complex judgmental situations. Since the subject is not asked to check every item on the list, there is a possibility of securing a large series of "don't know," or "doesn't apply" categories. There seems to be an obvious disadvantage in limiting weight on the items to +1 and 0, which may inhibit the potential discriminating ability of the items.

5. **Forced-choice ratings.** Forced-choice ratings do not ask the rater to judge either the existence or degree of existence of a trait or quality. The problem is to decide which of a pair of qualities exists to the greatest extent. In other types of ratings, the rater is asked to judge which of a list of qualities applies the

TABLE 4

Type	Components	Interpretation
Numerical. Estimate the amount of a quality present and give it a number proportional to its intensity.	A series of successive numerals or percents; descriptive terms may identify the numerals.	Combine rating of different subjects — central tendency and dispersion can be computed.
Graphic. Rate the amount of an attribute on some part of a defined line.	A dimension or dimensions and reference points. Descriptive words may anchor the parts of the scale.	Dimensions may be numbered and interpreted as numerical.
Cumulated points. List the qualities or check the list of qualities given.	A list of qualities or, alternately, observer may make his own list.	Count the frequencies of each category and interpret as in method of successive intervals.
Standard. Calibrated reference aganist which related stimulus can be compared.	A standard stimulus of known rating properties and a scaling method.	Same as successive intervals or paired comparison.
Choice. Observer is forced to indicate the "most," "least" or "most typical," etc., in the series or on the continuum.	A series of objects to be judged on any attribute.	A mode and mean choice. Can be treated as pair comparisons or first of rank order, etc.

"most" or "best" and which applies the "least" or the "worst" to an object or a situation. The theory of the forced-choice method is that the statistical significance of responses cannot be determined by the rater, and hence, the score cannot be affected by intent. The technique is to furnish some items for comparison that appear significant to the rater, yet which have little discriminatory value. The theory is that these items act as "suppressors" and tend to counteract the personal biases of the rater.

The greatest deterrent to the widespread use of the forced-choice method is the amount of effort required in developing an adequate instrument. Descriptions are first obtained of the factor or quality to be judged from the administrator. These descriptions are then analyzed into very short statements or cues. The statements are then empirically validated for their discriminatory, predictive, or preference values, tried out in experimental form, and finally, compared and modified with respect to an outside criterion. This has usually been a time-consuming operation and may not be justified.

TWO TYPICAL PROBLEMS

In conclusion, we will briefly review two problems of the type which confront food technologists daily. In the food industry the question of precise qualitative measurement is extremely important. Food processors are not content to know merely that a product varies. They wish to know also how and why it varies. Knowing how and why will permit corrective action and a better product. Our first example:

Let us examine the task of defining the ideal raspberry ice cream. One can start by collecting and studying a series of different commercial products via efficient application of panel techniques. Then, the components can be analyzed by rating methods, after which they are combined for reanalysis. From these data, the optimum color, flavor, odor, texture and other interacting qualities are known. These qualitative measures, in combination with preference studies, provide valuable information for guiding further research, manufacturing and marketing operations.

Since the objective of a food manufacturer is to please every consumer, his chances of success are increased in proportion to the extent of his knowledge of consumer reactions. He may learn from direct psychometric procedures that he can change his formula in such a way as to save money and, at the same time, gain wider sales. He can learn of the distinctiveness, the perceived value and, above all, the validity of his basic approach by a series of self checking scalar approaches.

A second example:

Consider the prevalent problem of estimating flavor intensity. If one wishes to learn from a panel which of 3 samples of a seasoning is most intense, he can elect one of several approaches. First, he might compare them directly at full intensity, or he may dilute all equally and compare. Alternately, he can establish the absolute threshold value of each. Finally, he can obtain a rating of the intensity of each sample on an absolute rating scale. If he is still not satisfied, other forms of mixing and comparison study may be pursued, depending upon the product and the precision required. Several standard psychophysical methods were discussed as they apply to measurement of intensity. Some of the methods described have advantages over the techniques in everyday use principally because they present a simple task for the panel member in which the influence of word meaning is minimized.

SUMMARY

In summary, we have outlined methods for rating the psychological properties of foods by psychophysical methods. The limitations, as well as the strength of standard rating scales, were presented in an attempt to guide the user of them. Great stress is placed on methods from the science of human behavior (psychology), only because panels are groups of human beings and psychologists over the past century have standardized many methods. In devising the methods, they have made ample provision for variation in order to permit study of specific stimulus properties. We must remember that panel measures are scientific measures and are subject to the rules of measurement.

A number of concepts are introduced which may be new to the food technologist. For example, the jnd is the quantal unit of psychophysics representing a *just noticeable difference*. Forced-choice, equal appearing intervals, successive intervals, average error, judgment time, and single stimuli are names of methods for which administrative and computational techniques have been thoroughly worked out.

A comparison is made between the familiar quality scoring techniques and the panel rating scale methods.

Finally, we would like to advance the idea that wider application of the scales described should satisfy the ultimate scientific criterion — usefulness.

LITERATURE CITED

1. Andrews, T. G. (Ed.) *Methods of Psychology.* 1948. Wiley, New York, N. Y.
2. Beebe-Center, J. G. Standards for use of the gust scale. *J. Psychol.*, **28**, 411-419 (1949).
3. Boring, F. G. *Sensation and Perception in the History of Experimental Psychology.* 1942. Appleton-Century-Crofts, New York, N. Y.
4. Edwards, A. L. *Experimental Design in Psychological Research.* 1950. Rinehart and Co., Inc., New York, N. Y.
5. Edwards, A. L. The scaling of stimuli by the method of successive intervals. *J. Appl. Psychol.*, **36**, 118-122 (1952).
6. Foster, D. Approaches to the panel study of foods and the need for standardization. *Food Technol.*, **8** (5) (1954).
7. *Food Acceptance Testing Methodology—a Symposium.* 1953. Sponsored by the Quartermaster Food and Container Institute for the Armed Forces and published by the Quartermaster Advisory Board, National Research Council—National Academy of Sciences, Washington, D. C.
8. Guilford, J. P. *Psychometric Methods.* 2nd ed. 1954. McGraw-Hill, New York, N. Y.
9. Jones, L. V., Peryan, D. R., and Thurstone, L. L. De-

velopment of a scale for measuring soldiers' food preferences. *Food Research*, 20, 512-520 (1955).
10. PERYAM, D. R., GIRARDOT, N. F. Advanced taste test method. *Food Eng.*, 194, 58 (1952).
11. PERYAM, D. R., PILGRIM, F. J. The hedonic scale method of measuring food preferences. (This Symposium).
12. RAFFENSPERGER, E. L., PERYAM, D. R., WOOD, K. R. Development of a scale for grading toughness-tenderness in beef. *Food Technol.*, 10, 627-630 (1956).
13. SCHUTZ, H. G. Effect of bias on preference. *Food Acceptance Testing Methodology, a Symposium* (1954).
14. STEVENS, S. S. (Ed.) *Handbook of Experimental Psychology*. 1951. Wiley, New York, N. Y.
15. STEVENS, S. S. On the averaging of data. *Science*, 121, 113-116 (January, 1955).
16. THURSTONE, L. L. *Psychophysical Methods*. Chapter 5 in T. G. Andrews (Ed.) *Methods of Psychology*, 1948. Wiley, New York, N. Y.
17. WOODWORTH, R. S. *Experimental Psychology*, 1938. Henry Holt, New York, N. Y.
18. WOODWORTH, R. S., AND SCHLOSBERG, H. *Experimental Psychology*. Revised ed., 1954.

Methodology of the Flavor Profile

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IN ACCEPTING AN INVITATION to speak about the methodology concerned with the operation of a Flavor Profile panel, all of our previous publications have been reviewed with the purpose of developing a more complete description of the methods and procedures required for the establishment of an effective Profile panel. The nature of the Flavor Profile and the theory which has been developed from its use were well described in several of our earlier publications *(1, 2, 3)*. The general organization and operation of a Flavor Profile panel have been discussed in detail in two recent publications *(4, 5)* so that any extended treatment of this phase of the method would be somewhat superfluous at the present time.

Concisely, the Flavor Profile method of analysis is a descriptive method which takes into consideration the total impressions of, first, the aroma and then the flavor-by-mouth of a product, as well as the independently recognizable aroma and flavor factors according to type, intensity, and order of perception. It uses panels of four or more members who have certain basic qualifications, such as normal smelling and tasting abilities, interest in flavor, reasonable intelligence, and special experience and training in flavor analysis. Training includes exposure to a variety of odor and flavor situations as well as instruction in practical techniques for sniffing and tasting and the rationale for these techniques.

Actually, the method of operating the panel is quite simple. Samples are presented under standardized conditions and are examined by standardized techniques. The independent findings of each panel member for both aroma and flavor are recorded and are also reported orally to the panel leader, followed by a round-table discussion devoted to clarification of descriptive terms. Additional panels are carried out, each with a particular objective, until all the principal characteristics of the product are established.

This disciplined descriptive analysis is carried out without the expression of any preference or final judgment as to the quality of the product involved. The interpretation and evaluation of findings is a separate function carried out by senior staff members who study the tabulated Flavor Profiles.

In a sense, evaluation by interpretation of the Profile of a product partakes of the expert tasters' approach in that it gives attention to the presence or absence of certain characteristics which denote quality. At the same time negative characteristics and off-flavors are weighed against the positive attributes. The Profile method departs from expert procedure in that the Profile taster reports only odor and flavor characteristics without making any final decision on quality.

While all of our previous publications have dealt rather adequately with the general method of developing Flavor Profiles and with interpretation of findings, we believe two essential aspects of the procedure and training have not been adequately described—that is, the basic method of training panel members and the methods used to develop an understanding of blended flavor.

DEVELOPMENT OF A PROFILE PANEL

Since 1949 we have carried out formal training programs with research departments of some 25 different companies in the general areas of foods, drugs, plastics, petroleum, paper, and rubber. During the course of this work we have experimented with different approaches and have developed a fair idea of the minimum amount and type of training which is required. Some of the principal problems involved in selection and training have been mentioned in previous publications, but it seems desirable to review the general approach in the light of our accumulated experience.

Selection of panel members. As stated earlier in this paper, panel members should have normal abilities, interest in flavor and odor, and intelligence. In addition, they must be made available for panel work. This latter qualification is obtainable only through management's consent, and forms the first basis for selection of potential candidates for training.

Current literature *(4)* explains how the other prerequisites for panel membership are explored. Taste ability is checked through performance in the tasting of sweet, sour, salty, and bitter media. Olfactory acuity is tested by the Elsberg technique *(6, 7)*. Interest level is indicated by odor-recognition tests and by personal interview. The interviewer also attempts to discover other qualifying attributes of the candidate.

Interest. There are some general difficulties which are inherent in all types of panel work, and one of the most important of these is the stimulation and maintenance of interest. In dealing with various research groups we have found that this is a serious difficulty in some cases and is often due to too frequent use of the panel, to the satiating nature of the product tested, or to the lack of satisfactory devices for maintaining interest.

There are several procedures which will help to avoid this difficulty:

1. It is essential to keep the panel constantly informed of the outcome of all tests in which they participate. This provision for maintenance of interest involves a simple form of recognition of ability, and it has been shown that both interest and ability increase constantly in standard scoring and judging procedures when the panel is thus informed.

2. A considerable amount of thought should be given to the number of panels which can properly be conducted during a working day. This will vary with the nature of the material under test. In our experience the number of panels has varied from one to six, depending principally upon the effect on the mouth.

3. Finally, the provision of a suitable panel room and atmosphere for testing, suitable recognition and respect for the taste-testing function, and in general the friendly support of management are also conducive to continued maintenance of interest.

Education of panel members. After selection of a group of interested and capable people and of a panel leader, provision should be made for adequate training of the members of the panel, and one of the factors assuring success is the provision of adequate time for training and participation in working panels. By reviewing the general procedure followed in training a panel when it is carried out by Arthur D. Little, Inc., the general scope of training can be visualized, although it is impossible to reproduce the exact training course within the scope of this article. It should be pointed out that our training program has the double purpose of training a panel and of developing individuals qualified for research on flavor and other problems.

Table 1 outlines the topics covered in the basic course on panel training. The immediate objective is to introduce the trainees to a subject to which they may have given little thought. This objective is usually achieved in a four-day course, which includes lectures, demonstrations, and opportunities to learn and use techniques under the supervision of experienced panelists. Part of this training is designed to develop familiarity with the descriptive language required; part is concerned with developing some understanding of the chemical nature of odorous and flavorful materials; part with the facility of taste and odor perception; part with the disciplines and procedures required for reproducible tasting and smelling; and part with the quantitative aspects of flavor and odor concentrations. All are designed to let the trainees lead themselves naturally into the Profile method.

In carrying out the basic training program we use a combination of round-table discussion periods and lectures by experienced members of the staff on the specific topics shown in Table 1, but the training program does include great emphasis on actual tasting and smelling of complex foods and beverages as well as examinations of specific single substances.

During this 4-day period we attempt to generate the enthusiasm and foster the interest and confidence which will carry the trainees through the coming months of training. On the last day they are given a program plan and schedule of practice media on which they are to develop Profiles. The Profiles resulting from the practice sessions to be conducted at their own laboratory will be compared with Profiles on the same media obtained by the experienced panel at Arthur D. Little, Inc. This comparison of findings enables us to evaluate the tempo and progress of the trainee panel. Usually, monthly visits are made to the trainees' location in order to continue the supervision and guidance and to provide encouragement and support.

At a suitable time during the first 6-month period depending on progress made, the panel returns to the Flavor Laboratory for a refresher course. This is outlined in Table 2. Problems specific to the trainee panel are emphasized, together with topics which will help to broaden their scope of activities.

TABLE 1

Outline of basic course in flavor analysis

Lecture and Study Topics	*Demonstrations and Trainee Participation*
Purpose of Course	Taste Thresholds
Physiology of Tasting and Smelling	Odor Thresholds via the Elsberg Method
Proposed Theories on Taste and Odor Perception	Odor Description
Odor and Chemical Constitution	Flavor Description
Flavor and Chemical Constitution	Description of Note Intensities
Philosophy of Flavor	Difference Panels
Definition of Flavor Terms	Flavor Profile Panel
Requirements for Panel Operation	*Independent Participation by Trainees*
Panel Room Design	Flavor Profile Panels (Criticized by ADL Faculty)
Functions of Panel Leader	Quiz
Theory of Odor Masking	
Introduction to Flavor Profile	
Odor Library and Reference Standards	
Pertinent Literature	

Upon returning to their own laboratory, additional exercises in flavor analysis are taken up and we continue to supervise the monthly conferences for a period of one year. A typical panel will usually be operating effectively at the end of 6 months, and some panels of unusual interest and ability may be effective in three months. The plan is self-perpetuating, for new members required to replace panel members can be trained by the panel leader and by the panel itself.

DEMONSTRATION OF BLENDING AND CHARACTER NOTES

The scond topic which requires 1 rther elucidation, especially for those attempting to initiate a program on Profile analysis without our assistance, is the concept of blended aroma and blended flavor. We recognize a need for some system of providing teaching materials which will enable research groups to set up a series of test materials having known odor and flavor characteristics. It is possible to suggest a number of perfume materials, essential oils, and flavoring materials which may serve this general purpose, but these usually are extremely potent in odor and flavor and do not represent the general amplitude and intensity characteristics which are found in commercial foods, beverages, and confections.

We have found it extremely stimulating to examine solutions of these materials at concentrations in the range of one to three times recognition threshold, which represent the odor and flavor levels commonly encountered in practical use. By mixing in simple ratios, these same solutions demonstrate the blending phenomenon and other important effects.

A study of mixtures may be accomplished in several different ways, and surprising results are sometimes obtained by titrating one near-threshold solution with another. In this way blending, neutralization, accentuation, and the development of interesting new combinations can be revealed. The subtle effects of one material on another can be seen more readily in working at these rather low levels of concentration.

Titration without maintaining constant volume offers a rapid method of screening possible combinations of two or more components, and the use of concentrated pharmaceutical waters enables one to dilute the titration mixtures to various threshold levels for odor and flavor examination. When a combination has been thoroughly explored in a preliminary way, a parallel series of separate solutions can be prepared to represent the more interesting flavor systems encountered during the titration. In this series the concentration of one component in terms of threshold levels may be held at a constant value while the other component is varied, a procedure which is almost impossible during continuing titration.

To summarize, the flavor and odor of aromatic materials at practical use levels may be explored by means of pharmaceutical waters. Interesting mixtures may be discovered by rapid titration studies and these may be studied in more detail by the preparation of constant volume solutions.

The general procedure for preparing aromatic waters stems from ancient pharmaceutical art and was designed originally as a rapid method of preparation of saturated solutions of rather insoluble materials, such as essential oils. Examples are water of camphor, rose, and peppermint. The official method is described in detail in the United States Pharmacopoeia *(8)*, but investigators unfamiliar with laboratory procedure may benefit by seeking the advice of an experienced pharmacist. The method employed for this study was as follows:

1. 3.0 g. of odorant or flavorant are intimately mixed in 5.0 g. of purified talc in a clean mortar with pestle.
2. 5.0 ml. of distilled water are added with mixing to yield a thick paste of smooth consistency.
3. 250 ml. of distilled water are added to the paste and the mixture is agitated rapidly by hand for 1 minute.
4. The suspension is allowed to stand for 2 minutes, then agitated for 1 minute, and allowed to stand for 2 minutes.
5. After vigorous agitation the suspension is filtered through fluted paper (Whatman No. 0, 18.5 cm.).
6. Increments of distilled water are passed through the talc bed until the volume of the crystal-clear filtrate measures 1 liter.
7. Aliquots of the pharmaceutical water are added to known volumes of distilled water in a flask of the size to be used in subsequent experiments; the flask is stoppered, swirled, and allowed to come to equilibrium; the column of air above the solution is sniffed. Threshold concentration is the minimum volume which, when added to distilled water, will permit full recognition of the odorant (flavorant) by the panel. Threshold is referred to as T. Multiples of this concentration are referred to as 2T, 3T, etc.

If these solutions are prepared from the same starting material by a well standardized procedure, the concentration of a freshly prepared solution is quite reproducible. Some of these solutions are not very stable, however, and should be prepared freshly for each series of tests covering a period of three or four days.

Flavor and odor examinations. About 30 different

TABLE 2

Outline of advanced training course

Discussions	impact, order of appearance, blend, mouthfulness, after-taste, etc.
Purpose of Course	Consumer Product Testing
Critique of Trainee Panel's Findings Since Basic Course	Physico-chemical Separation
Problems of Trainee Panels	
Lectures and Study Topics	*Demonstrations and Trainee Participation*
Aids to Odor and Flavor Analysis	The Use of Reference Standards
Methods for Studying Packaging Materials	Complex Flavor Situations
Flavor Compounding	Temperature Control
More Philosophy of Flavor	
Effect of Metals on Odors	*Independent Participation by Trained Panel*
Screening Methods	Several Profile Panels
Review of Terms: amplitude,	

odorants, including aromatic chemicals as well as essential oils, were prepared as pharmaceutical waters and examined at 3T concentration. First they were examined singly for the purpose of obtaining their odor Profiles and, incidentally, of training the panel members. Twenty-five milliliters of the respective pharmaceutical waters in known threshold dilutions were pipetted into 125 ml. Erlenmeyer flasks stoppered with corks wrapped in aluminum foil. The flasks were held for a moment at room temperature until equilibrium had been reached and then their contents were sniffed without being swirled.

Second, by the titration technique depicted in Table 3, pairs of the odorants were similarly studied for their effects on each other. About 300 pairs were examined, and it was found that their effects fell into one of the following five categories:

1. A + B: mixture in which some of the major odor notes of each odorant were suppressed or submerged
2. A + B: neutralization—in which the major notes of both odorants were nullifying recognizable characteristics
3. A + B: mixture in which some of the odor characteristics of one odorant were suppressed while identity of the other odorant survived
4. A + B: complete blend in which the identity of both odorants was so altered as to produce an entirely new odor.
5. A + B: partial blend in which both odorants retained some identity and a new odor was also produced

As suggested by Table 3, some of the most interesting pairs from the standpoint of odor construction were rose-spearmint, cassia-methyl salicylate, and diacetyl-vanillin. These pairs fit the fifth category—that is, a partial blend where an odor complex was created. Table 4 summarizes the findings for two of these pairs: the rose-spearmint combination, which to our knowledge does not exist in nature or in food products; and cassia-methyl salicylate, which may be the basis for some flavorings used in confections and dentifrices.

In both sets a zone was found where each odorant appeared to lose to some degree its identity in the formation of a complex. Although it is not known whether the formation of an odor complex is due to the formation of a chemical association complex and/or to the confusion of signals to the olfactory receptors, the fact remains that the types of odor phenomena outlined above do occur and in our experience they represent the complex systems normally encountered in both natural and processed products.

The peak of the art of building complexes and blending is to be found in perfumery. Like many natural floral aromas, a good perfume is composed of many odor-bearing components which together produce a blend consisting of a complex supporting a few describable character notes.

In a heretofore unreported study we were commissioned to improve the aroma of a pharmaceutical product which smelled strongly of the by-products of thiamine. The offensive odor was described as yeasty, sour, and beer-like, with a rubbery note. Minute additions of individual odorants, such as volatile oils, natural resins, and aromatic chemicals, produced a variety of results. Some odorants tended to suppress the sour note and some the yeasty note, while others suppressed sour and rubbery. By experimentation, a combination of odorants was discovered which suppressed all of the undesirable characteristics without developing any new and recognizable odor. This is an example of blending designed to suppress objectionable odors.

A few experiments were initiated to provide demonstrations of blending phenomena as they apply to flavor. Flavor is more complicated than odor because it includes not only the aromatics perceived when an edible substance is in the mouth, but also the tastes perceived by the mouth and the feeling factors in the mouth, throat, and nose. Preliminary tests showed that the flavor characteristics of these materials could be disclosed most readily in a simple sugar base. Sugar

TABLE 3

Scheme for titrating pairs of odorants at three times recognition level (3T)

Pairs	Odorants	Threshold (T) ml pharm water per 100 ml	Thrice threshold (3T) ml pharm water per 100 ml
	Concentrations		
1 A	Rose	0.15	0.45
1 B	Spearmint	0.15	0.45
2 A	Cassia	0.20	0.60
2 B	Methyl salicylate	0.75	2.25
3 A	Diacetyl	0.25	0.75
3 B	Vanillin	1.10	2.20

Constant volume mixtures

Flask No.	A ml.	B ml.	Ratio A/B
1	25.0	0	1/0
2	20.0	5.0	4/1
3	16.8	8.4	2/1
4	12.5	12.5	1/1
5	8.4	16.8	1/2
6	5.0	20.0	1/4
7	0	25.0	0/1

TABLE 4

Results of titrating two odorants

Flask No.	Ratio of A/B	Odor description	
	A = Rose; B = Spearmint		
1	1/0	oily rose	
2	4/1	citronella-like; lemon-rose	
3	2/1	soapy minty-rose	COMPLEX
4	1/1	undescribed blend (ylang-ylang?)	COMPLEX
5	1/2	undescribed blend	COMPLEX
6	1/4	neroli-like; minty and floral	COMPLEX
7	0/1	Spearmint	
	A = Cassia; B = Methyl Salicylate		
1	1/0	sweet fragrance + cinnamon (Cassia)	
2	4/1	spicy-minty	COMPLEX
3	2/1	blend: checkerberry leaves + phenol	COMPLEX
4	1/1	blend: checkerberry leaves + phenol	COMPLEX
5	1/2	low amplitude blend	COMPLEX
6	1/4	higher amplitude blend + me-sal	COMPLEX
7	0/1	me-sal	

patties flavored with known quantities of cassia and methyl salicylate were prepared. The patties provided physical substance as well as a sweet taste highly compatible with the essential oils under study.

Instead of pharmaceutical waters, alcoholic solutions of the flavorings were prepared which would produce a level of flavor of slight to moderate intensity (1-2 on the Profile scale of intensities) in the sugar patties. The alcoholic stock solution of oil of cassia was 5 per cent by weight; for methyl salicylate it was 10 per cent by weight.

The following procedure was employed for making flavored patties: A solution of 100.0 g. of cane sugar in approximately 35 ml. of distilled water was heated to 116° C. This clear solution was removed from the heat source and beaten with a glass rod until clouding began. Then 1 ml. of the flavoring was added and thoroughly mixed in. The flavored syrup was poured onto a sheet of aluminum foil, marked for cutting, and allowed to harden.

The panel examined the samples by taking standardized bites of the patty, chewing very rapidly, and noting the principal flavor characteristics. Table 5 summarizes the experiments conducted on the cassia-methyl salicylate sugar patties. Again a zone of complexity was found, and within the zone there were three ratios of flavorings where subtle differences were perceived.

It is not to be construed that this simple experimentation completes the story of blending. Because we have often stated that blending is a vital part of good flavor and a key to the construction of good flavor, we have attempted to outline in full the simplest kinds of approach to an understanding of blending. Interpretation of Flavor Profile tabulations and the development and improvement of products by means of the Profile approach depend on an understanding of the blending concept which cannot be gained except through experience. It is not possible to define the seasoning action of salt, sugar, or monosodium glutamate on food flavor without this concept. It is not possible to explain the action of vanilla in baked goods, custard, chocolate, or ice cream without this concept. We are certain that the favorable action of many other ingredients used for decades by master chefs in the creation of flavorful, non-satiating food dishes and by old-time pharmacists in the flavoring of intolerably tasting drugs, can be ascribed principally to blending.

DISCUSSION

Two important aspects in the development of an operating Flavor Profile panel have been presented in some detail—first, a general outline of the training program for panel members and, second, a method of preparing and using certain test materials which are valuable in demonstration and instruction. As we have indicated, this training program is not designed simply to qualify people as panel members, but it is intended to develop a well rounded knowledge of flavor and to qualify the individuals for laboratory research on diversified odor and flavor problems. Success in the program depends to a large extent on the stimulation of continuing self-education, and the scope of background material is essentially the same for both technical and non-technical people.

The training program begins with screening and selection of potential candidates for the purpose of discovering persons with normal ability in tasting and smelling and also for the purpose of selecting, by formal tests and interview, individuals having more than average interest in odor and flavor. The majority of the people tested have shown normal acuity and sensitivity. Ability to identify odors and tastes and to recognize the principal odor and flavor characteristics of materials is apparently closely associated with what we call interest. This qualification is valuable for day-to-day participation in analytical flavor panel work. With a good degree of interest and motivation, a panel can also progress more rapidly in the training program, and various devices for promoting and maintaining interest are suggested.

As a supplement to the plan for panel training, we have described for the first time a method of preparing and using aromatic pharmaceutical waters as a means of demonstrating the phenomenon of blending and the closely associated features of the Flavor Profile. The advantage of this approach is that spices, condiments, and aromatic flavoring materials can be studied while working at the levels normally used in foods, beverages, and confections. By the mixing of near-threshold solutions in simple proportions, accentuation, suppression, complete neutralization, and the development of entirely new blended complexes can be demonstrated. We believe that this technique should prove valuable to all individuals seeking new understanding and more scientific approaches to the very complicated art of flavor and odor development.

TABLE 5

Flavor titration of (a) cassia and (b) methyl salicylate in sugar patties

No.	ml of alcoholic solutions per 100 g of sugar		Volume ratio	Flavor description		Calc wts per 100 g sugar (grams)	
	A	*B*	*A/B*			*A*	*B*
1	1.0	0	1/0	cassia + sweet		.039	0
2	0.80	0.20	4/1	cassia + sweet		.031	.016
3	0.66	0.33	2/1	sugar sweet blended; mint-cassia	COMPLEX	.026	.026
4	0.50	0.50	1/1	blended candy-mint	COMPLEX	.020	.040
5	0.33	0.66	1/2	meat blended; candy-mint	COMPLEX	.013	.052
6	0.20	0.80	1/4	slightly blended me-sal	COMPLEX	.008	.063
7	0	1.0	0/1	methyl salicylate; less sweet		0	.079

LITERATURE CITED

1. Anonymous. Flavor Profile describes food flavors in easily understandable terms. *Food Processing*, 11, 30 (1950).
2. Cairncross, S. E., and Sjöström, L. B. Flavor Profiles—a new approach to flavor problems. *Food Technol.*, 4, 308 (1950).
3. Cairncross, S. E., and Sjöström, L. B. Flavor Profiles—a method of judging dairy products. *American Milk Review*, 13, 42 (1951).
4. Caul, J. F. The Profile method of flavor analysis. *Advances in Food Research*, 7, 1956. Edited by E. Mrak and G. F. Stewart. Academic Press, Inc., New York.
5. Caul, J. F., Cairncross, S. E., and Sjöström, L. B. The Flavor Profile in review. *Food Technol.* (In press).
6. Elsberg, C. A. *et al.* The sense of smell. I. A new and simple method of quantitative olfactometry. *Bulletin of the Neurological Institute*, New York, 4 (1) 1 (1935).
7. Elsberg, C. A. *et al.* The sense of smell. VII. The odorous substances to be used for tests of the olfactory sense. *Ibid.* 4 (2) 286.
8. U. S. Pharmacopeia XV (1955), page 820.

Consumer Acceptance Methodology:

One vs. Two Samples

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Consumer food acceptance and preference can be determined directly by the frequency and quantity of consumption of a product. However, considering the complexity of food production and new product development, forecasting the acceptability of a food by the foregoing methods would be impractical if not impossible. The alternative is to present the new or improved food product under consideration to a representative group of consumers for evaluation.

Evaluation techniques used to obtain these consumer opinions must be planned carefully. The evaluation of a product can be secured in two ways: (a) quantitative measurement of the voluntary consumption of food by a selected group of people, unaware of the study, such as those reported by Bell *(3)*, and Jack and Haynes *(12)* on the acceptability of bread and (b) measurement of consumer acceptability by a verbal or written response. The latter, based on sensory evaluation of one or more samples, is the more frequently employed technique. The present paper is directed toward a controversial aspect of consumer methodology, i.e., the number of samples presented for evaluation at one time.

Whether food samples are evaluated in the home, in an institution, or by mass survey technique, the investigator must decide how many samples should be presented at one time. Generally, no more than two samples are presented since more than two may confuse the consumer *(4, 7, 13)*. A few cases have been reported in the literature where more than two samples have been presented simultaneously. Bliss, Anderson, and Marland *(5)* obtained consumer preferences for 4 samples of ice cream by a ranking procedure. Triangle tests have been used by Bell *(3)*, Carlin *(6)* and Berg, Filipello, Hinreiner, and Sawyer *(4)* on breads, angel cakes and wines, respectively. In the wine studies, the triangular method was found to be unsuited for consumer testing because of the additional supervision required in conducting the test, as well as confusion on the part of the tasters.

Multiple-sample presentation for preference or acceptance is a more common practice among laboratories and research stations for small-scale consumer tests *(15)*. However, in the above mentioned cases, the objective is an elimination procedure for selection of one or more samples from a series for presentation to a large-scope consumer panel.

If the product is completley new, with no market competition, the only alternative is single sample presentation using a quality rating scale. Hedlund, Albrecht, and Whatt *(11)* recommended the single sample technique for comparison of products which, although very similar, differed in features such as shape, size, or packaging material. Unless these specific variables are under study, however, they could influence the response to the quality factor being investigated.

Two main points of view on the subject of single *vs.* paired stimuli predominate. Advocates of the single stimulus proclaim it to be a more natural condition of testing as well as being simple both from the operator's and consumer's standpoint. Those individuals recommending paired stimuli believe a more valid and precise comparison is achieved.

There is some evidence that the single stimulus method results in as precise a preference measurement as does the paired technique. Using the hedonic scale, Bayton *(2)* and Bell *(3)* were able to achieve precision by single stimulus presentation of citrus juice and bread, respectively. Pfaffmann *(17)* has demonstrated that various thresholds and preferences for various brown breads were obtained with the same accuracy by both single and constant stimuli. In-

vestigations in other fields, such as psychometrics and psychophysics, have illustrated comparable results with the single and paired stimuli techniques *(1, 14, 21)*.

A paired stimuli situation suggests that a more conscious and discriminating consumer attitude is encouraged. Although this procedure is most widely used for preference measurements *(15)*, there is little evidence in the literature reporting it as being more precise. Filipello *(8)* obtained significant differences between wines of varying sweetness by a paired-hedonic methodology, but when the same wines were submitted singly, no significant differences were obtained.

Hedlund *et al. (11)* suggested that the "degree of difference" between samples becomes an influencing factor when deciding between single and paired stimuli presentation. These authors demonstrated this factor in a study wherein the difference in percent preference between two cereals was greater when the samples were presented simultaneously than when presented singly. Filipello *(8)* reported identical ratings for wines varying by 1% sucrose when evaluated singly. When the wines varied by 3% sucrose, the ratings differed in the same direction as ratings obtained by the paired technique.

The effect of serving order in simultaneous presentation is a factor which has been observed by most workers in the field of food acceptance. However, only recently has this effect been investigated in successive sample presentation. Using the hedonic rating scale, Hanson *et al. (10)* found that judges rated succeeding samples lower than the first sample when a lapse of time between samples ranged from 5 minutes to 2 days. This same effect is present in simultaneous presentation. On the other hand, Schwartz and Pratt *(19)* demonstrated a greater preference for the last sample presented with increasing effect for wider intervals of time when a preference-difference scale was used. Since both of the above studies were conducted with laboratory personnel, further investigation of the problem on a more realistic consumer level would be of value.

When does a technique cease to become one of single stimulus, but rather successive paired or multiple stimuli? When a series of samples is evaluated singly by the same consumer, can the results be interpreted as those of single stimulus? One solution might be to use different population samples for each of the series of products.

Hedlund *et al. (11)* presented data indicating the somewhat exaggerated differences obtained when two products differing in overall quality level were compared simultaneously. In the same report, these authors demonstrated the inflation of ratings when samples were presented singly as compared to multiple stimuli.

A comparison of results obtained by single and paired stimuli techniques from a mass panel consumer survey is reported in the present study. The investigation was a continuation of a study to determine the sweetness-acid-flavor relationship in fruit products.

EXPERIMENTAL

A mass panel survey was conducted at the California State Fair in September, 1956, to determine the effect of addition of citric acid on the acceptability of, and preference for, canned cling peaches. The advantages afforded by the use of this method of mass panel evaluation of food products and the reproducibility of results have been reported by several investigators *(9, 20)*.

Diced cling peaches of the Gaume variety were packed under rigid control with variations in addition of sucrose and/or citric acid *(20)*. The chemical characteristics of the four samples submitted for evaluation are tabulated in Table 1.

Three evaluation techniques were applied in the study: (I) single stimulus, hedonic rating scale, (II) paired stimuli, hedonic rating scale, and (III) paired stimuli, preference. The hedonic scale used in designs I and II, developed by Peryam and Giradot *(16)*, included nine structured levels ranging from "like extremely" through "neither like nor dislike", to "dislike extremely". In the paired preference design, the participant indicated a preference for "sample 1" or "sample 2".

The response sheet for each of the 3 designs included the following questions: age group, sex, height and weight, and frequency of use of canned peaches. Additional space was provided for comments.

Alternation of the three techniques was maintained throughout the 12-day period of the fair. For the paired stimuli designs, a balanced procedure was followed in presenting the six pair-combinations, with care taken to serve an equal number of reverse order combinations.

Population sampled. Table 2 presents the distribution within designs of age group and sex of the 6,012 fairgoers who participated in the survey. Each participant evaluated only one sample or one pair of samples in any one design.

Testing Accommodations. Space in the Foods and Hobbies Building of the State Fairgrounds was rented for the survey. A booth was constructed with 6 partitioned serving windows through which the samples were served to the participants. In order to reduce the possibility of another judge's influence, all possible sample combinations were served simultaneously within each design.

RESULTS

Designs. In this particular presentation, the results

TABLE 1

Chemical characteristics of canned peaches

		A	B	C[3]	D[4]
Ingoing:	° Brix	45°	55°	55°	65°
	Added acid[1]	.....	.....	.472	.117
Cut-out:	° Brix[2]	22.8°	26.3°	26.3°	28.4°
	Acid[1]	.341	.335	.483	.375
	° Brix/acid	67	79	54	76

[1] % citric anhydride.
[2] Soluble solids measurement of pulped peaches by refractometer.
[3] Addition of .472% citric acid to syrup at time of canning.
[4] Addition of .117% citric acid to syrup at time of canning.

of the investigation concerning design technique in a comparison of the rank preferences of the samples was of prime interest. This information is presented in Table 3, by age group and sex classification. Numerical values of 9 through 1 were assigned to the likeness levels of the hedonic scale. The average ratings listed for design II and the percentages for design III were obtained by combining the results of the three paired comparisons in which each of the 4 samples appeared. Although the number of all paired presentations of each sample in each classification were not equal, the slight variations would not affect a change in results.

Considering only the total population results, Sample C was preferred in all 3 designs. Analyses of variance of the incomplete block designs revealed the paired preference to be most precise in establishing differences among the samples, followed by the single stimulus and paired hedonic, respectively. Both age group and sex variations in response are most apparent in design II, which accounts for the lack of significance among the samples.

Close observations of these results indicate a different rank-order for the three remaining samples (A, B, D) in each design. Analyses of each of the 6 possible comparisons, using Student's "t" test for designs I and II, and "chi square" for design III, again indicated that more precise preference was measured by paired preference (Table 4). There was one case where statistically significant preferences were reversed by two methods. In 12 out of the 42 comparisons by age group, sex, and total population classifications, the results indicated a reversal. The agreement with respect to direction of preference between any two techniques within each classification was comparable.

The single stimulus hedonic technique resulted in precision which approximated that of the paired preference. The observation is in accord with findings of Pilgrim and Wood *(18)* who found a closer agreement between the two methods. Considering the differences in the population sampled in the two studies regarding the tasters' previous experience with the two procedures, this slight difference in precision of agreement is understandable.

TABLE 2

Age and sex frequency table

Design	Sex	Number of participants				
		Age group[1]				Total
		1	2	3	4	
I	Male	218	138	404	57	874
	Female	234	160	641	116	1078
	Total	452	298	1045	173	1952
II	Male	350	163	318	91	922
	Female	253	206	552	159	1170
	Total	603	369	870	230	2092
III	Male	408	147	251	68	817
	Female	319	148	434	177	1151
	Total	727	295	685	245	1968
Total participants						6012

[1] Age group 1—under 16
2—16 to 25
3—25 to 50
4—over 50

TABLE 3

Over-all comparisons—age and sex groupings

Class	Design	No. of significant comparisons	Sample			
			A	B	C	D
Age group:						
1	Single[1]	0	8.13	7.85	8.07	8.04
	Double[1]	0	7.41	7.44	7.41	7.51
	Paired[2]	1	46	51	50	53
2	Single	0	7.69	7.63	7.77	7.54
	Double	0	7.37	7.08	7.39	7.41
	Paired	1	48	53	55	43
3	Single	2	7.77	7.80	7.81	7.59
	Double	2	7.33	7.36	7.53	7.29
	Paired	3	41	50	57	51
4	Single	1	7.87	8.11	8.33	7.82
	Double	1	7.66	7.65	7.69	7.86
	Paired	0	43	53	50	53
Sex group:						
Male	Single	0	7.73	7.77	7.78	7.68
	Double	1	7.32	7.39	7.38	7.46
	Paired	2	42	52	54	51
Female	Single	2	7.93	7.86	7.94	7.73
	Double	0	7.47	7.35	7.58	7.42
	Paired	2	46	51	52	51
Total population	Single*	2	7.85	7.82	7.88	7.71
	Double	0	7.40	7.37	7.49	7.44
	Paired***	3	44	51	54	51

* .05 probability level of significance.
*** .001 probability level of significance.
[1] Average ratings.
[2] Percent preference.

A higher rating of all responses in single stimulus presentation can be noted in Table 3 by comparing the average scores of each sample in designs I and II. This effect is emphasized by the fact that the ratings obtained in the individual paired comparisons, by both age group and sex classification, were in no case as high as those obtained with design I. Another outstanding observation, which has been reported many times in the literature, was a bias for the first sample tested. A comparison of this effect in designs II and III is made in Table 5. It appears that the phenomenon of serving order effect occurs somewhat equally in both designs due to the relatively small difference in acceptability among the samples.

One characteristic of the hedonic scale technique, whether applied to single or multiple stimuli, is the obtainment of an estimate of the acceptability level of a food. However, this feature becomes irrelevant when products which are enjoying a high level of acceptance are evaluated. In the present study, when relatively small alterations were made in a product which did not affect the acceptability level *per se*, the application of the hedonic scale was more apt to lead to psychological confusion of the consumer. The effect of this factor was apparent to the investigators during the operation of the survey. In the paired hedonic design, participants were frustrated when they "liked" the two samples equally, but had a preference for one, and could not indicate this on the score sheet. Thus, when they recorded their reactions, more emphasis was placed on completion of the response sheet than on precision in noting a difference in degree of likeness.

TABLE 4

Individual paired comparisons (total population)

Pair	Design		
	I (single sample)	II (double hedonic)	III (paired preference)
	Average rating		Percent preference
A	7.85	7.45	42
B	7.82	7.39	58**
A	7.85	7.34	44
C	7.88	7.47	56*
A	7.85*	7.43	46
D	7.71	7.48	54*
B	7.82	7.38	49
C	7.88	7.53	51
B	7.82	7.29	48
D	7.71	7.51	52
C	7.88**	7.47	53
D	7.71	7.31	47

* .05 probability level of significance.
** .001 probability level of significance.

TABLE 5

Effect of serving order double hedonic and paired preference

Age group	Number of comparisons with reversed preference due to serving order [1]	
	Double hedonic	Paired preference
1	4	4
2	2	3
3	3	3
4	5	3
Sex		
Male	5	5
Female	4	5
Total	4	6

[1] AB vs. BA.; AC vs. CA; AD vs. DA; BC vs. CB; BD vs. DB; CD vs. DC.

Although the rating scale is composed of relatively simple, straightforward terms, there were a number of cases where a participant would check several of the terms. This confusion resulted in discarding approximately 8% of the response sheets in design II, 3% in design I, as compared to less than 1% in design III.

Age groups. The responses classified by age groups can be seen in Table 3. It is apparent that the 25- to 50-year old participants were least affected by the design variation in their rank order of sample preference. This group was consistent, by all methods, in rating Sample C first, B second, followed by A and D with one reversal in these last two samples. This third age group displayed the most discriminating ability by the greater total number of significant comparisons. It should be noted that this particular group constituted the largest number of participants.

There was a definite effect of age on level of response, regardless of sample variation. The youngest and oldest groups indicated a higher acceptability for all samples. Group 1, however, was more critical than the older participants in the paired hedonic presentation. The 16- to 25-year olds were the most critical in both the single and paired hedonic presentations.

Sex. An indication of a difference between the responses of males and females regarding design variation was a slightly wider range of average scores by the females (Table 3). There was also a difference in the level of scoring, with females tending to score all samples higher.

Samples. A consistent preference for Sample C by the total population sampled indicated that the same sweetness-level preference of approximately 25 to 26° Brix as determined previously *(20)*, is maintained, but that the addition of acid increased the acceptability (Table 1). This is generally true in all classifications in Table 3. The exceptions were found in the youngest and oldest age groups, and in the male population where the tendency was toward a preference for the sweetest sample. The slight preference for sample A, the least sweet, by the under-16-age group in design I results, is somewhat questionable.

SUMMARY

The application of the three sample presentation techniques for a comparison of four peach samples varying in apparent sweetness revealed similar results. It was noted, however, that the degree of difference was a criterion in choosing one over the other. Because the results of the survey were not very highly significant, these observations and indications were based mainly on trends.

The paired preference technique appeared more precise in establishing significant preferences among a series of samples with relatively small acceptability gradients than did the hedonic rating scale, by either single or paired stimuli.

Applicability of the hedonic rating scale to a mass consumer survey, as the one described above, appears to have some restrictions. The number of ballot discards due to confusion of the participants was greatest for the paired hedonic rating method, followed by the single hedonic and paired preference, respectively. The apparent precision of the single stimuli over paired hedonic stimuli may be accountable to the confusion factor. Higher ratings for all samples were obtained by the single stimuli as compared to the responses by the paired hedonic presentation.

With a population of such large heterogeneity as that surveyed, the time and supervision required in explaining the scale is of questionable value. The fact that canned peaches are a highly acceptable food indicates that the rating scale used was not the most precise tool in obtaining a rank preference.

Variations in response due to age and sex differences are apparent among the three presentation techniques and within any one technique. Less consistency in discrimination and higher acceptability ratings were found among the youngest and oldest age groups. Females displayed a wider range and higher level of ratings than did the males.

The fairgoers maintained a consistent preference for a sweetness level of 25° to 26° Brix in canned cling paches. The addition of citric acid appears to increase the acceptability and preference.

Acknowledgment

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LITERATURE CITED

1. Barnhart, E. N. A comparison of scaling methods for effective judgments. *Psychol. Rev.*, **43**, 387–395 (1936).
2. Bayton, James A. Ability to discriminate and preferences in regard to canned orange juice that varied in Brix-acid ratio. U.S.D.A. Bureau of Agr. Econ. (1950).
3. Bell, H. P. Consumer preferences among bakers' white bread of different formulas. U.S.D.A. *Marketing Res. Report 118* (1956).
4. Berg, H. W., Filipello, F., Hinreiner, E., and Sawyer, F. M. Consumer wine-preference methodology studies at California Fairs. *Food Technol.*, **9**, 90–93 (1954).
5. Bliss, C. I., Anderson, E. O., and Marland, R. E. A technique for testing consumer preferences, with special reference to the constituents of ice cream. Conn. Agr. Exp. Sta. *Bull. 251* (1943).
6. Carlin, Agnes Frances, Ayres, John C., and Homeyer, Paul G. Consumer evaluation of the flavor of Angel cakes prepared from yeast-fermented and enzyme-treated dried albumen. *Food Technol.*, **8**, 580–583 (1954).
7. Crocker, E. C., Sjöström, L. B., and Tallman, G. B. Measurement of food acceptance. *Ind. Eng. Chem.*, **40**, 2254- (1948).
8. Filipello, F. Factors in the analysis of mass panel wine preference data. *Food Technol.*, **10**, 321–326 (1956).
9. Filipello, F., Berg, H. W., Hinreiner, E., and Webb, A. D. Reproducibility of results in consumer wine-preference surveys. *Food Technol.*, **9**, 431–432 (1955).
10. Hanson, H. L., Davis, J. G., Campbell, A. A., Anderson, J. H., and Lineweaver, H. Sensory test methods. II. Effect of previous tests on consumer response to foods. *Food Technol.*, **9**, 56–59 (1955).
11. Hedlund, Gweneth J., Albrecht, Bernice, and Whatt, R. L. Single product or paired comparison consumer tests, which should you use? Paper presented at 14th Annual Convention of Institute of Food Technologists (1954).
12. Jack, E. L., and Haynes, Vesta M. Consumer preferences for bread containing different levels of non-fat dry milk solids. *Food Research*, **16**, 57–61 (1951).
13. Nair, John H. Mass taste panels. *Food Technol.*, **3**, 131–136 (1949).
14. Newhall, S. H. Comparability of the method of single stimuli and the method of paired comparisons. *Am. J. Psychol.*, **67**, 96–103 (1954).
15. Personal communications.
16. Peryam, D. R., and Girardot, N. F. Advanced taste-test method. *Food Eng.*, **24**, 58 (1952).
17. Pfaffmann, C. An experimental comparison of the method of single stimuli and the method of constant stimuli in gustation. *Am. J. Psychol.*, **47**, 470–476 (1935).
18. Pilgrim, Francis J., and Wood, Kenneth R. Comparative sensitivity of rating scale and paired comparison methods for measuring consumer preferences. *Food Technol.*, **9**, 385–387 (1955).
19. Schwartz, Noel, and Pratt, Cornelia H. Simultaneous vs. successive presentation in a paired comparison situation. *Food Research*, **21**, 103–108 (1956).
20. Simone, Marion, Leonard, Sherman, Hinreiner, Elly, and Valdes, Rose Marie. Consumer studies on sweetness of canned cling peaches. *Food Technol.*, **10**, 279–282 (1956).
21. Wever, E. G., and Zener, K. E. The method of absolute judgment in psychophysics. *Psychol. Rev.*, **35**, 466 (1928).

Evaluating Flavor Differences in Canned Foods

I. Genesis of the Simplified Procedure for Making Flavor Difference Tests[a]

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The National Canners Association in June, 1951, at San Francisco, California, sponsored a meeting of industrial technical personnel in the fields of raw products and quality control to consider the need for a cooperative research program on the effects of applied pesticides on the flavor of canned foods. Off-flavors in canned foods had been reported which were thought to be due to the application of pesticides to the growing crop. An industry advisory committee, appointed at the conference, met with the research personnel of the Departments of Entomology, Pomology, Vegetable Crops, and Food Technology at the University of California to discuss a cooperative research program. The advisory committee strongly recommended that any promising pesticide for canning crops be tested for its effect on flavor, before it was recommended by the Agricultural Extension Service or Experiment Station for general use. A cooperative research project was outlined and plans were made to treat pears, tomatoes, and carrots with various pesticides. Samples were to be canned by the canning industry under the supervision of

[a] The cooperators on this study are:
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Elly Hinreiner and Marion Simone, University of California
E. E. Lockhart and Carol Campbell, Massachusetts Institute of Technology
W. A. Maclinn and Elizabeth F. Stier, Rutgers University
Willard B. Robinson, New York State Agricultural Experiment Station
Edward Ross and Margaret M. Hard, State College of Washington
Lois Sather, Oregon State College
Mardell D. Tompkins, American Can Company
K. G. Weckel and John J. Birdsall, University of Wisconsin
R. C. Wiley and A. Kramer, University of Maryland

the Food Technology Department of the California Experiment Station. The canned samples were to be tested for flavor differences by the Acceptance Laboratory of the Department of Food Technology immediately after processing and after 6 and 18 months of storage.

Similar industry and Agricultural Experiment Station meetings were held in 1952 in states where canning crops were important to discuss the problem of the effect of pesticides on the flavor of canned foods.

Samples of sweet potatoes from plots treated in 1952 were canned and sent to a number of universities in the fall of 1952 for flavor evaluation. The project at the University of California was described to enlist their interest and cooperation in determining the possibility of obtaining uniformity between laboratories in evaluating flavor differences on the same test samples. Considerable interest in such a program was shown by all the universities contacted and a meeting was held at the time of the National Canners Convention in February, 1953, to discuss a program which might lead to greater uniformity among laboratoriees in evaluating flavor differences in canned foods.

A special conference was held during the 1953 N.C.A. Convention to discuss subjective methods of evaluating flavor changes in canned foods caused by pesticides applied to the growing crop. Methods of selecting and training of judging panels, methods of preparation and presentation of food samples, and statistical procedures were thoroughly discussed by food technologists, horticulturists, and statisticians from a number of universities and the food industry. It was the unanimous recommendation of this group that studies should be initiated toward developing a simple uniform flavor difference procedure which could be utilized not only by experienced food laboratories but also by research workers in institutions where food laboratories were not available.

The National Canners Association was asked to act as a coordinating agency or clearing house for this project. Each cooperator made available to all other cooperators and the N.C.A. a detailed description of the flavor evaluation method being used in his laboratory. Dr. Hinreiner of the University of California was delegated by the cooperators to prepare a tentative draft of a uniform method after a thorough study of all the methods. As a guide to Dr. Hinreiner the cooperators agreed that the uniform method for making flavor difference tests should be as simple as possible. Since the triangular method *(4, 6, 7)* had been used by a number of the laboratories with good results, it was proposed that a modification of this method be tested first. The changes included were designed to provide supplementary information on the magnitude of flavor differences and also a measure of objectionableness. Judges were instructed to check the preferred sample(s), to quantify the difference in flavor and indicate whether or not it was objectionable or not objectionable (Fig. 1).

Date_____ Project No._____

Name of Judge_____ Product_____

Sample	Check Duplicates*	Check Preferred Sample(s)

Check one of the following:

0. No detectable difference at all.
1. Slight difference—not at all objectionable.
2. Slight difference—slightly objectionable.
3. Definite difference—definitely objectionable.

* Place check marks opposite two and only two of the sample numbers. If necessary, **guess** which two samples are identical.

Figure 1. Judge's score sheet used in first trial. (1953)

1953 TESTS

In the summer of 1953, the Food Technology Department of the University of California prepared canned samples of pureed pears harvested from two treated and one untreated experimental plot of the Department of Entomology. One case of each treatment (coded) and two cases of the control, after 7 months' storage, were sent to each of the cooperating laboratories for flavor evaluations.

Ten laboratories participated in the experiment and the results were sent to the National Canners Association for coding and assembling. These data were then submitted to a group[b] representing the Food Committee of the American Society for Quality Control for objective and critical statistical analyses.

Results of the 1953 tests. The 1953 data showing the ability of the 10 laboratories to separate treatment from control in the modified triangular method and showing the preferences of judges who correctly separated the samples are presented in Table 1.

TABLE 1
A summary of 1953 results

Treatment	Number of laboratories		Preference[1]	
	Significant separations	Non-significant separations	For control	For treatment
			Percent of judgments	
A	3	7	68	32
B	3	7	53	47

[1] Based on correct separations.

It was concluded from the first year's tests that although there might be slight differences in flavor due to the two pesticide treatments, the differences between them were not great enough to accurately assess the procedure or the performance of the panels.

[b] Glenn Burrows, Amihud Kramer, Howard Stier, and William Weiss.

Only 42.3% of all judgments showed correct separations for Treatment A, 42.5% for Treatment B.

The Food Committee of the American Society for Quality Control after thoroughly studying the data from the 1953 tests suggested that (1) the scoring system be modified, (2) additional columns be provided on the score sheets, and (3) instructions to the judges should be more complete and definite as to the test procedure. They felt that very clear instructions should be provided on the judge's score sheet so that there would be no need for interpretations on the part of the test supervisors.

1954 TESTS

In the fall of 1954 a revised modified triangular method for making flavor difference tests of processed fruits and vegetables was prepared. This procedure incorporated most of the suggestions and ideas of the cooperators and the Food Committee of the American Society for Quality Control. The new score sheet contained 6 columns which provided the judges with the opportunity to indicate flavor difference scores, objectionableness ratings, and flavor preference (Fig. 2). Judges were instructed not to indicate an objectionable flavor unless they actually detected an objectionable flavor, regardless of the degree of flavor difference found. Every effort was made to eliminate biases in the score sheet and scoring procedure. Detailed instructions for the test supervisor concerning the order of presentation and replication of samples *(3)* were added to the 1954 instructions. The value of including flavor preference and objectionableness ratings was believed to lie in the opportunity to study, in detail, the performance of individual judges in the different replicates. These additional ratings were not intended in any way to reflect *"consumer"* preference but rather to provide additional information from a triangular test without the necessity of additional samples or effort.

The product used in the 1954 test was canned pears. They were harvested from plots treated by the Entomology Department, and canned by the Food Technology Department of the University of California. The revised procedure was used by each of the cooperating laboratories during the early winter of 1954. The results which were summarized and eval-

(Rate flavor only, ignore all other differences)

Date_____ Project No._____

Name of Judge_____ Product_____

Treatment Code No._____

Sample (1)	Check Duplicates (2)	Check Preferred Sample(s) (3)	Flavor Difference Score (4)	Objectionableness Score of Less-Liked Sample(s) (5)	Remarks (6)

Instructions for Judge

Column 1: Enter the letter or numerical designation of the three samples.

Column 2: Place a check mark opposite those two of the three samples that you think taste alike. Check only **Two.** If necessary, **guess** which two samples taste alike.

Column 3: Place a check mark on the line opposite the sample you prefer. If you have no preference as to flavor, write in 0.

Column 4: This column is intended to indicate the degree of the flavor difference between the two duplicate samples and the other sample in the set of three. Use the following scoring system:

0—No detectable difference; checked duplicates by guess.
1—Slight difference in flavor.
2—Moderate difference in flavor.
4—Much difference in flavor.

Column 5: Use the following scoring system in this column:
(Do not assign an objectionable score to the less preferred sample in this column unless you actually detect an objectionable flavor.)

0—Not objectionable.
1—Slightly objectionable flavor.
2—Moderately objectionable flavor.
3—Very objectionable flavor.

Column 6: Enter in this space any comments concerning the samples that you think important or appropriate.

Figure 2. Revised judge's score sheet used in second trial. (1954)

uated by the Food Committee of the American Society for Quality Control are presented in Table 2.

It was evident from the data submitted that different interpretations of the scoring procedures had occurred among cooperators and judges and therefore either the instructions were still not sufficiently explicit or verbal amplifications of the instructions by test supervisors were misleading to the judges. Many judges apparently quantified *preference* rather than *flavor difference* when the instructions called for a *flavor difference rating*, but no quantification of preference. It was obvious from these results that again there was not sufficient flavor difference between the two pesticide-treated samples to evaluate the test procedure. Only 42.7% of all judgments showed correct separations for Treatment R-7-4, 42.0% for Treatment R-7-5.

TABLE 2
1954 results on triangulations, preferences, and objectionableness scores

Treatment	Number of laboratories		Proportion of judgments showing preference		Objectionableness scores[1]	
	Significant separations	Non-significant separations	For control	For treatment	For control	For treatment
			Percent of judgments			
R-7-4	4	7	44	66	34	23
R-7-5	3	8	58	42	20	40

[1] Sum of scores for correct separations for all laboratories.

1955 TESTS

A general discussion of the 1953 and 1954 test results by all the cooperating food technologists and representatives of the Food Committee of the American Society for Quality Control at the N.C.A. Convention in February, 1955, led to the appointment of a subcommittee representing both groups to recommend test materials and procedures for the 1955 test. This subcommittee met and drew up tentative modifications of the modified triangular method based upon the ideas and suggestions presented at the joint

FLAVOR DIFFERENCE EVALUATION

Judge's Score Sheet

Date_____ Product_____

Project_____ Treatment or Can Code_____ Panel Replicate_____

Name of Judge_____ Code No. or Letter for Judge_____

Separate for Flavor Only

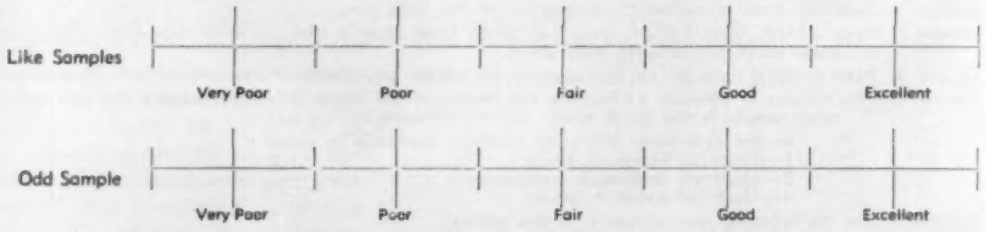
Sample	Check Like Samples*	Flavor Difference between odd and like samples		Did you check by guess?
(1)	(2)	(3)		(4)
_____	_____	____None	____Slight	Yes_____
_____	_____	____Moderate	____Much	No_____
_____	_____			

* Check by guess if no difference is detectable.

5. If you checked a **Moderate** or **Much** in the flavor difference column (No. 3), then indicate below whether you consider either the odd sample or like samples to have an undesirable flavor.

   Odd Sample: Yes_____ No_____ Like Samples: Yes_____ No_____

6. **Rate for flavor only.** Place a check mark above either a short or long line on the scale below to indicate how you rate the like samples and the odd sample.



7. (a) Did you detect any kind of difference, other than flavor, between the samples?

   Yes_____ No_____

   (b) If "Yes," what kind of difference? _____

Figure 3. Revised judge's score sheet used in final modified triangular test. (1955)

conference. The principal modifications were the deletion of columns 3 and 5 for flavor preference and objectionableness ratings. Experience in 1953 and 1954 demonstrated that inclusion of a preference rating apparently biased or confused the judges in their later evaluations of flavor difference. However, judges were given the opportunity to acknowledge but not quantify the presence or absence of an undesirable flavor on the revised form. Scales for rating the flavor of the odd and like samples were added to the judge's score sheet as well as a place to indicate and describe any differences other than flavor that might be noted between the samples in the test. The tentative revision was sent to all cooperators for review and criticism. The subcommittee met again later in the spring of 1955 in Washington and carefully reviewed all the suggestions of the cooperators and prepared a final draft of the modified triangular method, which was again circulated to all cooperators and adopted in the form shown (Fig. 3).

The Food Committee of the American Society for Quality Control suggested that a multiple comparison procedure *(5)* be used for comparison with the modified triangular method. It was pointed out that a multiple comparison procedure would provide not only an accurate estimate of the existence of a real flavor difference between samples but also of the degree of the difference. It was noted that the triangular procedure *per se* tells the user only that there there is a difference. The attempt to quantify this flavor difference by modification of the triangular procedure had proved unwieldy and required a complicated score sheet. In addition, only one-half as many samples and judgments were required for the same number of replications using the multiple comparison procedure as for the modified triangular method. The food technologists agreed that this procedure should be tested, and the agreed upon form (Fig. 4) was duplicated and sent to all cooperators along with the modified triangular method for use in the 1955 tests.

Procedure

The joint subcommittee recommended that samples of tomato juice be prepared and canned by W. A. Gould of Ohio State University, using an additive procedure developed by E. H. Hinreiner of the University of California. The treated samples were prepared by adding two different quantities of an extracted pesticide to a given volume of tomato juice before processing. Canned samples of each of the 2 treatments and the untreated control were distributed to all those cooperating in the test. Previous work at the Oregon Experiment Station on the influence of the size of juice samples on panel efficiency indicated that the optimum sample was 1½ ounces of tomato juice. Each cooperator was asked to use this sample size to obtain greater uniformity in the experiment. Instructions on panel selection, judging environment, testing procedure, etc., were sent to all the cooperators in the project.

FLAVOR DIFFERENCE EVALUATION
Judge's Score Sheet

Product_____ Date_____

Treatment_____ Laboratory_____

Judge's Name_____ Judge's No._____

INSTRUCTIONS: Check on the scale below the intensity of flavor difference which you are able to detect in each of the samples when compared with the reference or control sample. Next, place a check in one of the columns at the end of the line to indicate whether, to you, the sample is acceptable or unacceptable in flavor. The reference sample may be re-tasted whenever necessary.

INTENSITY OF FLAVOR DIFFERENCE

	None	Slight	Moderate	Large	Extreme	Acceptable	Not acceptable
Sample No.____							
Sample No.____							
Sample No.____							
Sample No.____							
Sample No.____							
Sample No.____							

Figure 4. Judge's score sheet used for multiple comparison test. (1955)

Modified triangular method. Specific instructions on the tabulation of data from the individual judge's score sheets were furnished each cooperator along with summary tabulation forms. Space was provided on these forms for recording the accuracy of separations, flavor difference values, and the flavor rating scores of each judge in each replicate for both the treated and control samples in a given triad.

Each judge checked on his score sheet the word *none, slight, moderate* or *much* to indicate the flavor difference between odd and like samples. Prior to transcription to the summary tabulation form, the supervisor assigned numerical values of 0 for *none*, 1 for *slight*, 2 for *moderate*, and 3 for *much*. The data for each judge and replicate were then entered on the summary tabulation form. Flavor difference values were tabulated for all triangulations including incorrect as well as correct separations. When 25% or more of all of the judgments for a single treatment indicated an undesirable flavor, the supervising judges were requested to tabulate the frequency of such designations and submit with the other data for statistical analysis.

Before transcribing flavor ratings to the summary tabulation form, the supervisor assigned numerical values of 0 to 10 (in order, poorest to best) to the ratings.

Each cooperator in the project was requested to record on the back of the summary tabulation sheets the order of presenting the samples in each triangulation given each judge in each replicate. This was necessary in order to assign properly the flavor rating values to the treatment or to the untreated control.

Multiple comparison procedure. The form used in this test provided a quantification of the "intensity of flavor difference" for each sample and also the opportunity for each judge to indicate whether he felt the flavor of the sample was acceptable or not acceptable. The degree of flavor difference between a "reference" sample and the test sample was indicated by each judge by a check mark along a segmented horizontal line. Below the line, from left to right, appeared the words *none, slight, moderate, large,* and *extreme.*

It was reasoned that if the true flavor difference was to be rated accurately by the judges a standard or reference sample was required as a basis for comparison. For this reason a reference sample *(1, 8)* (the untreated sample) was given to each judge to serve as the basis for the *none* score on the judge's score sheet. The procedure provided that each judge be presented a randomly arranged triad replicated four times. Each replicate included one sample each of the 2 treatments and a coded control which was the same as the reference sample. Judges were instructed to compare these individually with the reference sample and to check the degree *(2, 9)* of flavor difference. On completion of the tests the supervisor assigned integers of 1 to 10 (left to right) to the vertical lines on the rating scale (see Fig. 4) before posting on the summary tabulation form.

TABLE 3

1955 Summary of results in modified triangular tests by laboratories (Product: canned tomato juice)

Lab no.	Treatment	% Correct Separations	Mean flavor difference[1]	Mean flavor rating[2]		Total no. evaluations (n)
				Treated sample (T)	Untreated sample[3] (C)	
(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*
1	A[4]	53.3	1.47	4.73	6.08	60
	B[5]	70.0	1.62	4.73	4.77	60
2	A	41.7	1.03	6.33	6.83	60
	B	48.3	1.07	5.85	5.97	60
3	A	48.1	1.04	6.00	7.22	27
	B	71.4	1.57	5.19	8.19	21
4	A	50.0	1.30	4.98	6.10	60
	B	58.3	1.57	4.62	5.50	60
5	A	48.3	1.52	5.12	6.17	60
	B	55.0	1.63	4.15	6.07	60
6	A	56.7	1.53	4.67	6.97	30
	B	76.7	1.83	3.37	6.57	30
7	A	70.0	1.12	5.05	7.38	60
	B	85.0	1.92	3.32	7.42	60
8	A	56.7	1.28	4.67	6.07	60
	B	70.0	2.03	3.13	5.82	60
9	A	53.3	1.93	4.37	6.03	30
	B	63.3	2.07	3.30	6.50	30
10	A	50.0	1.43	3.30	5.27	30
	B	90.0	2.30	2.40	5.40	30
11	A	65.0	1.23	5.20	6.43	60
	B	83.3	1.85	3.43	6.00	60
Mean for all labs.	A	52.9	1.33	5.02	6.42	
	B	68.3	1.73	4.02	6.06	

Signif. level	% Correct necessary for signif.	L. S. D. values for comparing any two lab. means		
5 %	46.7	.23	.56	.45
1 %	50.0	.34	.85	.68
0.1%	55.0	.45	1.13	.90

N. B.—All above values based on $n = 60$; L. S. D. values on $t_{.05} = 2$, $t_{.01} = 3$, $t_{.001} = 4$.

[1] Rated difference in flavor between samples judged to be different in a triangulation where 0 = none, 1 = slight, 2 = moderate and 3 = much.

[2] A quantitative measure of desirability of flavor where 0 is the lowest possible rating (very poor) and 10 is the highest (excellent).

[3] The mean flavor rating of the untreated sample is a triangulation with the treatment indicated in column 2.

[4] Treatment A—low conc. additive
[5] Treatment B—high conc. additive
} Each in a triangulation with untreated sample(s).

RESULTS AND DISCUSSION

Data obtained from the cooperators utilizing the two flavor evaluation procedures were subjected to analysis of variance. Data for all laboratories were combined in a single analysis of variance. The differences necessary for significance shown in Tables 3 and 4 are based on the residual variance composed of 2nd order and higher interactions. A summary of the modified triangular method results is presented in Table 3 with accompanying L.S.D. (least significant difference) values for evaluating the data. In Table 4 is presented a summary of the results from the multiple comparison procedure by laboratories. The significance of the results obtained in both the triangular and the multiple comparison tests is summarized in Table 5.

Modified triangular method. As shown in Tables 3 and 5, using the modified triangular method, 8 of the 11 laboratories were able to separate the low concentration treatment (Treatment A) from the control. All eleven of the laboratories correctly identified the high concentration treatment (Treatment B) when compared with the control. In the latter instance, significance was at the .1% level for all laboratories except one. Five laboratories (1, 2, 5, 6 and 9), however, did not give a significantly higher flavor difference score to the high concentration treatment when compared with the low concentration treatment where each of the two treated samples was presented with the untreated sample in separate triangulations.

Seven out of the 11 laboratories gave a significantly higher flavor rating to the low concentration treat-

TABLE 4

1955 Summary of multiple comparison test data by laboratories (Product: canned tomato juice)

Lab no.	Low conc. additive (Treatment A)		High conc. additive (Treatment B)		Control		No. reps.	No. judges	Total ratings (n)
	Mean flavor difference (M. F. D.)	% Not acceptable	Mean flavor difference (M. F. D.)	% Not acceptable	Mean flavor difference (M. F. D.)	% Not acceptable			
1	3.7	31.7	5.9	65.0	2.5	8.3	4	15	60
2	3.3	8.3	5.9	43.3	2.7	1.7	4	15	60
3	2.6	5.6	6.9	83.3	1.8	0	2	9	18
4	3.3	28.3	4.4	60.0	1.7	5.0	4	15	60
5	3.7	.....	5.7	.....	2.4	.....	4	15	60
6	3.3	28.1	7.1	84.4	1.9	4.7	4	15	60
7	3.9	40.0	7.6	93.3	1.3	0	4	15	60
8	3.2	25.0	5.5	61.7	1.8	1.7	4	15	60
9	5.0	26.7	7.2	78.3	2.1	3.3	4	15	60
10	3.9	40.0	7.0	93.3	1.9	10.0	2	15	30
11	3.2	30.0	7.4	88.3	2.0	1.7	4	15	60
Weighted mean	3.6***	27.3	6.3***	73.5	2.0***	3.6			

Difference necessary for significance between any two lab M. F. D. values:

Significance level	*L.S.D.*
5 %	.6
1 %	.9
0.1%	1.2

(*Based on* $n = 60$ and $t_{.05} = 2$, $t_{.01} = 3$ and $t_{.001} = 4$.)

*** Significantly different at 0.1% from other weighted treatment means.

(Flavor difference code: 1 = None, 3 = Slight, 5 = Moderate, 7 = Large, and 9 = Extreme)

ment (A) than the higher one (B) (Table 3). Four laboratories, however, did not consider the flavor to be different in spite of the considerable difference in the quantity of additive present in the juice.

Multiple comparison procedure. When the multiple comparison procedure was used, 10 of the 11 laboratories gave the low concentration treatment (A) a mean flavor difference score that was significantly higher than the score for the control or untreated sample (Tables 4 and 5). All 11 laboratories assigned a significantly greater mean flavor difference value to the high than the low concentration samples. With one exception, all of these mean flavor difference values were significant at the 0.1% level. The percentage of each of the 3 samples which were judged to be non-acceptable were 3.6% for the control, 27.3% for the low additive, and 73.5% for the high additive treatment. Each of these percentages were significantly different from each other at the 1% level.

TABLE 5

Summary of the significance of data for the 1955 tests

Lab no.	Treatment	Modified triangular test			Multiple comparison test	
		Accuracy of separation T vs. C	Flavor difference A vs. B	Flavor rating A vs. B	Flavor difference	
					T vs. C	A vs. B
(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*
1	A	**	N.S.	N.S.	***	***
	B	***			***	
2	A	N.S.	N.S.	N.S.	*	***
	B	*			***	
3	A	N.S.	*	N.S.	N.S.	***
	B	***			***	
4	A	**	*	N.S.	***	**
	B	***			***	
5	A	*	N.S.	**	***	***
	B	***			***	
6	A	**	N.S.	**	***	***
	B	***			***	
7	A	***	***	***	***	***
	B	***			***	
8	A	***	***	***	***	***
	B	***			***	
9	A	*	N.S.	*	***	***
	B	***			***	
10	A	N.S.	***	*	***	***
	B	***			***	
11	A	***	***	***	***	***
	B	***			***	

N.S. = non-significant
* = sig. @ 5% level
** = sig. @ 1% level
*** = sig. @ 0.1% level

Modified triangular method vs. multiple comparison procedure. In the ability of judges to correctly recognize the high concentration treatment when compared with the untreated control there is a slight advantage in favor of the multiple comparison procedure—all 11 laboratories correctly identified the high concentration treatment at the 0.1% level of significance compared with 10 of the 11 in the modified triangular method. (The 11th laboratory attained significance at the 5% level using the triangular procedure.) The difference between the 2 procedures is more evident in the results obtained with the low concentration treatment. With the low concentration samples the multiple comparison test resulted in 9 of the 11 differentiating between the samples at the 0.1% level of significance, while only 3 of the 11 attained this high level of proficiency using triangular comparisons.

Another important advantage of the multiple comparison procedure is that it requires only half as many judgments and samples as the modified triangular method for the same degree of replication.

In the multiple comparison test, all of the participating laboratories obtained flavor difference values for the two treated samples that were significantly different from each other at the 1% level or higher (Table 5, Column 7). In triangular comparisons,

however, only 4 laboratories obtained values significantly different at a comparable level of significance (Column 4). This may be explained in part by the differences in scale range, 1 to 10 versus 0 to 3, utilized in the 2 tests, but it is doubtful that the entire difference in these results relative to the two procedures can be attributed to this scale difference.

Laboratories 1, 2, 5, 6 and 9 showed the greatest improvement in ability to detect flavor differences between the two treated samples and between treatment and control when they employed the multiple comparison test instead of the triangular test. Use of the multiple comparison test resulted in no improvement in any respect by labs 7, 8 and 11. In laboratories 7 and 8, however, the panels received special training with tomato juice to which the pesticide under study had been added, and laboratory 11 used a highly selected panel which was derived from taste panel personnel having a history of 3 years reproducible performance in tests on tomato juice with a number of different insecticide treatments.

For a given degree of precision the multiple comparison procedure apparently requires less extensive panel screening and training than the modified triangular method. It should be pointed out, however, that even though many laboratories did not give specialized training to their taste panels, all of the cooperating laboratories have had considerable experience in taste panel work. Anyone conducting flavor difference tests for the first time must necessarily do some screening to eliminate judges who are taste blind with reference to the material to be evaluated as well as judges having a decided prejudice against the particular product to be used. Where differences in flavor between the treated and control samples are small, panel training and selection become more important.

The primary objective of this cooperative project was to develop a *simplified procedure* for making flavor difference tests of canned foods where the crop has been treated with pesticides. It was agreed that the use of a selected and trained panel would not substitute for consumer acceptance evaluation. A comparatively small but selected and trained panel could, however, readily detect major flavor differences of importance to the consumer. Perhaps of even greater importance, if such a panel found no flavor differences, certainly a consumer panel would find none. If, on the other hand, in actual practice this panel found a relatively small but statistically significant flavor difference as a result of treatment, samples could then be submitted to a consumer acceptance panel for further evaluation. A small and specially selected panel employing a simplified procedure therefore can be used as an objective screening panel to evaluate accurately and rapidly the influence of applied pesticides on the flavor of canned foods.

CONCLUSIONS

When the same flavor difference evaluation procedure was used by a number of laboratories, the following factors were found to be important in obtaining uniform results:

(a) Detailed but clear instructions to judges and supervisors,

(b) Standard procedures for recording and summarizing data,

(c) A uniform and preferably simple procedure for analysis of the data.

The multiple comparison procedure using a reference sample is more accurate and efficient than the modified triangular method in evaluation of flavor differences, especially when differences are not very great.

Special advantages of the multiple comparison procedure over the modified triangular method are that it:

(a) Detects smaller differences between treated and untreated samples,

(b) Is more efficient when panels have not been specially selected and trained,

(c) Requires half as many samples for the same replication, thus making it simpler and easier to conduct with a corresponding saving in time and money.

Use of the multiple comparison procedure with reference sample resulted in uniform flavor difference evaluations among the food laboratories located in different geographical areas of the country.

LITERATURE CITED

1. Blanchard, E. L., and Maxwell, M. L. Correlation of subjective scoring with sugar content of frozen peas. *Food Research*, **6**, 105-155 (1941).
2. Cartwright, L. C. and Nanz, R. A. Organoleptic evaluation of foods. (Abstract) *Spice Mill*, **71** (8) 47-48 (1948).
3. Cox, G. M. Statistics as a tool for research. *J. Home Econ.*, **36**, 575-580 (1944).
4. Hening, J. C. Operation of a routine testing group in a small laboratory. *Food Technol.*, **3**, 162-163 (1949).
5. Kramer, Amihud and Ditman, L. P. A simplified variables taste panel method for detecting flavor changes in vegetables treated with pesticides. *Food Technol.*, **10**, 155-159 (1956).
6. Peret, H. Taste test panels. *Natl. Provisioner*, **121** (20), 12-13 (1949).
7. Roessler, E. B., Warren, J., and Guymon, J. F. Significance in triangular taste tests. *Food Research*, **13**, 503-505 (1948).
8. Tomkins, R. G. Organoleptic tests in the food industry. II. The use of a "Tasting Panel" for assessing the culinary quality of dried vegetables. *Chemistry & Industry*, **11**, 167-168 (1949).
9. Tomkins, R. G. Grading and quality of vegetables. *Chemistry & Industry*, **7**, 107 (1948).

Evaluating Flavor Differences in Canned Foods

II. Fundamentals of the Simplified Procedure[a]

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UPON COMPLETION of a four-year study of modifications of several standard procedures for making flavor difference evaluations of canned foods, the cooperators recommend the use of the simplified procedure herein described. The procedure is described in considerable detail primarily for the benefit of those inexperienced in taste panel work. Therefore, an example of a judge's score sheet, summary tabulation form, and method for analysis of data are included.

The procedure is comparable to the multiple comparison procedure described by Kramer *(1)* except a reference sample is used for the purpose of more accurately evaluating flavor differences.

Use of this method is recommended by the cooperators for the following reasons:

1. It is simple to use for both supervisors and judges.
2. It provides an effective method of screening and selecting judges.
3. It requires the minimum amount of time and number of samples.
4. It provides an accurate measurement of the *degree* of flavor difference between samples.
5. It provides an indication of the flavor acceptability or non-acceptability of treatments in the test.
6. It provides a quick and easy, yet accurate, method of statistical analysis of data.

Panel selection and training. Judges for use in taste panel work may be selected from a number of sources. Those used by experienced food laboratories have been students, staff members, wives of staff members, and in some cases housewives from the surrounding area. In general, no one should be asked to serve on a taste panel who is not acquainted with the product through normal use. In no case should anyone be asked to serve on a flavor evaluation panel who has a strong dislike for the product to be tested. Furthermore, no one should be asked to serve who is not interested in the work and willing to give a conscientious, unbiased judgment of flavor. In soliciting taste panel members, the purpose of the test should be fully explained as well as the objectives in order to enlist the full cooperation of the judges.

Experience obtained in this study indicates that 60 flavor evaluations for each treatment will probably be ample to detect with 99% accuracy whether there is an actual flavor difference due to treatment. In practice, 15 judges and 4 test replications have been found convenient in obtaining the desired 60 judgments per sample. In some instances, however, it may not be possible to obtain 15 judges for use on a taste panel, and it would, therefore, be necessary to increase the number of replications to obtain the desired number of judgments with fewer judges.

Final selection of judges from prospective panel members meeting the above specifications may be made by one of two procedures. One method is to use a simple screening test employing the product to be tested to determine the ability of the individuals to detect flavor differences in the product. The supervisor of the experiment should prepare samples of the product to be tested for use in this screening test. Samples with flavor differences may be prepared by adding some flavoring agent such as sugar, salt, lemon juice or even sauerkraut juice at several concentration levels. If the product under study is not a liquid or homogeneous mixture such as applesauce, the product should be reduced to this state by grinding prior to incorporating the flavoring agent and thorough blending of the samples with the additive. The judgment of the supervisor will be necessary in order to establish suitable levels of sweetness, saltiness or sourness in the test product. It is suggested that two treated samples containing a medium and a high level of the flavoring agent and a control, untreated sample, be used. In this way the supervisor should be able to eliminate those persons unable to detect the high level of treatment. The supervisor's judgment will be required to decide whether those unable to detect the medium level additive should be used on the panel. It is suggested that in the screening test the samples be submitted under code in several replications to prospective judges in order to obtain a measure of the judges' consistency in evaluating actual flavor differences. Those lucky enough to differentiate treated from control in one presentation may then be eliminated by replication of the screening test. Only those persons should be used on the taste panel who are able to detect consistently the flavor difference which the supervisor considers necessary.

The alternative method for selecting panel members which has been utilized by a number of food laboratories involves presentation of the actual test samples to 25 to 30 potential judges initially selected because of their interest in the project. Four replications are presented, and at the end of the experiment the supervisor eliminates the records of those judges who are unable to detect any flavor difference between samples by employing the procedure for evaluating judges described in the example presented later. With this procedure of selecting panel members, after the test has been repeated several times, a historical record can be obtained of each judge's performance. This

[a] The cooperators on this study are listed in Part I of this study.

provides an excellent screening procedure for selecting future taste panel members. If a number of flavor difference tests are to be conducted by the supervisor, and if adequate test samples are available, this procedure will be the most satisfactory from the standpoint of time and effort expended.

A judge who has a cold or other indisposition which might impair his or her ability to taste or smell should not be used in flavor evaluation tests. Judges should also be requested not to eat or smoke within 30 minutes prior to each panel session. Otherwise, no restriction — such as age, sex, occupation ,etc. — need be placed on panel membership.

Judging environment. The test should be conducted in a quiet, clean, odor-free room at a temperature of approximately 72° F. This room should be equipped with separate booths for each judge. Temporary booths of a suitable nature can be constructed out of pressed wallboard on top of a standard laboratory table. These booths can be made in a fashion similar to the dividers used in egg and bottled goods cartons. By slotting or grooving the sections, they can be assembled easily for temporary use and dismantled for convenient storage when not in use. Walls of the booth should be at least 20 inches high, and a minimum width of 30 inches should be allowed for each judge. The cross dividers should extend 6 to 8 inches beyond the edge of the table. On a laboratory table measuring 42 inches by 10 feet, it will be possible to provide booths for 4 judges on each side of the table. The use of booths even of this simple type creates the necessary private atmosphere for each judge to evaluate the test samples.

Taste panel sessions should be held preferably sometime between 9 and 11 o'clock in the morning and 2 and 4 o'clock in the afternoon. For practical reasons, judges should be allowed to come in to make the evaluations any time during a half-hour period or less if the samples must be served warm. No time limit should be set for an individual's judgment.

Sample preparation and serving. Methods employed in preparing and serving samples depend partially on the nature of the commodity. In the original preparation it is advisable to prepare approximately 3 times the quantity of the control material as of any of the other treatments. This will compensate for use of the control sample as a reference, as a coded control in the presentation, and for possible preliminary panel screening. At the time of the test, all cans or lots within each treatment or control should be combined and mixed thoroughly to avoid inter-can variation within given treatment lots. If the material to be tested is already diced or pureed, or is a liquid, or occurs normally in small pieces such as peas, beans, etc., no further preparation is necessary. Material in relatively large pieces, such as pear halves, sliced peaches, whole beets, etc., should be diced prior to serving. Fruit and other foods normally eaten cold should be served at room temperature. Those foods that are normally eaten hot should be served hot. It is important that all samples in the same replicate be at exactly the same temperature at the time of their presentation to the judges. The sample size presented should only be large enough to permit an evaluation of its flavor. Previous work with tomato juice has indicated that a 1½ ounce serving of a juice is sufficient. No seasoning other than salt or sugar normally used in the canning process should be added.

Samples presented judges for flavor evaluation should be coded, employing the numbers provided in Table 2. These numbers have been so selected that no treatment will have the same designation in successive replicates nor will the numerical order of treatments be the same. First digits have been assigned, however, to indicate the replicate and thus facilitate the supervisor's tabulation of the data.

After samples have been coded, those of the same replicate should be presented to any individual judge at the same time. Arrangement of samples at the time of presentation should be random, and the judge should be allowed to evaluate the samples in any order he chooses.

Tasting procedure. Judges should be instructed to taste each sample slowly and to re-taste samples as often as necessary in any order. The judge is also permitted to taste the reference sample as often as he deems it necessary to determine the degree of flavor difference. Judges should be provided with water so that they may rinse their mouths between samples if they so desire.

Judges may be given 2 replications of a given test at one session. In practice it has been found possible to run 2 replicates in the morning and 2 in the afternoon.

Primary objective of the test is to determine and quantify the degree of flavor difference between any of the samples and the reference. Judges are instructed to state whether this flavor difference is acceptable or unacceptable to them personally. This information provides the supervisor with additional information on the practical significance of the flavor difference.

The judge's score sheet, Figure 1, provides space for evaluating up to 9 samples for a given replicate presentation. Judges are asked to indicate by a check mark in the appropriate box in each vertical column the intensity of flavor difference between the sample being judged and the reference. Adjectives at the left of the columns describe the flavor difference as *none, slight, moderate, large* and *extreme*. Boxes are provided between each of these descriptive adjectives so that individual judges may indicate a half-way point between the two descriptive terms in describing the flavor difference felt to exist. At the base of each column, boxes are provided so that each judge may check whether in his opinion the sample is acceptable or not acceptable in flavor. It is recommended that a separate score sheet be used for each replicate presentation regardless of the number of samples involved to avoid possible confusion in later tabulation of the data and speculation on the part of the judges regarding replicate similarities.

At the completion of test, the supervisor should assign numerical scores of 1 to 9 to the flavor difference ratings checked on each judge's score sheet.

Figure 1. Flavor difference evaluation.
Judge's Score Sheet

Test Code_____ Date_____

Judge's No. _____ Replicate_____

INSTRUCTIONS

(1) Enter at the head of each column the code number of each sample in the test.
(2) Determine by flavor comparisons with the reference sample the degree of flavor difference for each numbered sample.
  (a) If you **do not detect any flavor difference,** place a check (V) in the box below opposite the word **None.**
  (b) If in your judgment **any flavor difference exists,** place a check (V) in **one** of the other eight boxes opposite or between the term(s) which best describes the **degree** of flavor difference.
(3) After rating the flavor difference, place a check in one of the two boxes at the bottom of the column indicating whether the flavor of the numbered sample is **acceptable** or **not acceptable to you.**

N. B.—The reference sample should be re-tasted as often as necessary to determine the **degree** of flavor difference for each sample.

Degree of Flavor Difference	Sample Number								
None	☐	☐	☐	☐	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐	☐	☐	☐	☐
Slight	☐	☐	☐	☐	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐	☐	☐	☐	☐
Moderate	☐	☐	☐	☐	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐	☐	☐	☐	☐
Large	☐	☐	☐	☐	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐	☐	☐	☐	☐
Extreme	☐	☐	☐	☐	☐	☐	☐	☐	☐
Acceptable	☐	☐	☐	☐	☐	☐	☐	☐	☐
Not Acceptable	☐	☐	☐	☐	☐	☐	☐	☐	☐

Judge's Initials_____

Values are assigned the flavor ratings in sequence from 1 = *none* to 9 = *extreme*. Numerical code designations for the samples should also be replaced by an assigned letter or word which will identify the individual treatments in all replications. Numerical flavor difference ratings are then transcribed to the form for summary tabulation (as shown in Table 1). Scores are entered opposite the proper treatment by judge and replicate. If the judge has indicated the flavor was not acceptable, place an asterisk next to the score on the summary tabulation form.

Analysis of data. Use of the appropriate statistical analysis is important in the proposed interpretation of taste test panel results. Since the procedure described is a measurements procedure rather than an attribute procedure, it is especially important to use statistical analysis in order to fully capitalize on the advantages of the method. Sometimes statistical analyses are not employed because the user is not familiar with the procedures or they are too tedious and time-consuming. During recent years, there have been developed a number of short-cut procedures for the statistical analysis of data, most of which are based upon the use of the range as a measure of variance in the data. Tukey's "quick and easy" procedure is one that has been frequently used (*3, 5*). It is simple and yet accurate. This method of analysis has been outlined in considerable detail in an example in this paper. Its use is recommended in the statistical analysis of data from the multiple comparisons procedure, because it has been found upon comparison with standard statistical procedures to give essentially the same results.

All data obtained from each of the 11 cooperating laboratories were summarized and combined in a consolidated analysis of variance using the standard method. In addition, a separate analysis of variance was computed for each of the 11 sets of data. In each case a significant interaction of judges × treatments was found. Under such conditions the appropriate variance for testing the significance of different treatments is the interaction variance. The fact that judges × treatments interaction exceeded the 1% level of significance in 8 laboratories and the 5% level in the other three strongly indicates that this will occur in most, if not all, taste test procedures where new pesticides are tested for their flavor effects. For this reason it is appropriate to use the range in scores between judges as a basis for testing treatment differences in Tukey's short-cut method.

Data for the multiple comparisons test for each of the 11 laboratories were subjected to the Tukey procedure using the range as described in the following pages. Results obtained by the Tukey procedure were then compared with those obtained, using the standard analysis of variance where the judges × treatments interaction was used in testing the significance of treatment differences. The least significant difference (L.S.D.) values calculated by the 2 procedures were invariably quite close. The average difference between the L.S.D. values for all 11 laboratories was less than 1%.

The Tukey method of analysis permits evaluation of results by simply adding the appropriate totals, the ranges (difference between highest and lowest values), and multiplying the sum of the ranges by a factor obtained from a reference table. All computations may be performed quickly without the need for calculating machines. The summary tabulation form (Table 1) has been designed specifically for use with Tukey's

"quick and easy" analysis. As an example, the data from one of the cooperators (Laboratory 4) has been entered on the summary tabulation form, together with the necessary totals and ranges, and is presented in Table 1. Accompanying the data is a step-by-step illustration of the analysis by the Tukey method.

When all the data for all judges, treatments, and replicates have been properly entered in the summary tabulation form, compute and enter in the designated position on the form the following:

A. For each judge:

1. The *sum* of the scores in all of the replicates for each treatment. For example, for Judge 1, the sum of the scores for Treatment A is 12, for Treatment B, 18, etc.

2. The *range* (difference between the highest and lowest score) within each treatment (*i.e.*, Judge 1, Treatment A, the range is 2, and for Treatment B, 4, etc.),

3. The *grand sum of the ranges* computed in 2 above, *i.e.*, for Judge 1 it is $2 + 4 + 1 = 7$.

4. The *grand range of the treatment sums* computed in 1 above, *i.e.*, the highest treatment sum for Judge 1 occurred in Treatment B *(18)*, the lowest sum in treatment C *(6)*. The difference between these two is the *grand range* or 12 for Judge 1.

5. Calculate the overall significant difference (O.S.D.) between treatment sums as follows: Enter Table 3 and obtain the appropriate factor in the 5% column for the number of replicates and treatments used. For example, in the illustration (Table 1) the number of replicates being 4 and the number of treatments, 3, the factor at the 5% level of significance is 1.25. Enter this factor on the summary form and multiply the grand sum of the treatment ranges for each judge by this factor. The product which is the O.S.D. is then entered at the bottom of the column for each judge, *i.e.*, for Judge 1 it is $1.25 \times 7 = 8.8$. A comparison of this product with the grand range of the treatment sums will indicate whether or not the judge rated the various treatments significantly different. The range between the highest and lowest treatment score should be greater than the O.S.D. value, *i.e.*, for Judge 1 the grand range of treatments sums is 12, which is higher than the O.S.D. value of 8.8. Whenever the range between the highest and lowest treatment sum for a given judge is equal to or less than the O.S.D. value, it indicates lack of ability to distinguish between any of the treatments.

6. Evaluation of judge performance: It will be noted in Table 1, after completing the calculations for O.S.D. values for the 15 judges, that judges 3, 6, 8, 12, 14 and 15 had grand range of treatment sums which were equal to or lower than their individual O.S.D. values at the 5% level. These judges, therefore, were unable to distinguish flavor differences, and in the illustration (Table 1) their data were eliminated from further consideration.

B. For each treatment:

1. Add the sums of replicate scores for each of the judges not eliminated. For example, the total of the sums for Treatment A for the nine remaining judges is 136, for B, 191, and for C, 49. These figures should be entered in the total column to the right side of the summary tabulation form.

2. Compute the range of the sums for the remaining judges in each treatment and enter this value in the column on the right side of the summary tabulation form headed Range of Judge Sums. In this example, for Treatment A the highest sum, 23, was given by Judge 13 and the lowest sum of 8 by Judge 9. The range is, therefore, 15 and is entered on the next column on the same line as the 136.

3. Count the number of asterisks in all of the replicates for a single treatment for the 9 remaining judges and record the number in the column at the extreme right of the sheet headed Number Not Acceptable. In the example given in Table 1, the number of asterisks for Treatment A for 9 judges is 13. For later evaluation of the significances, this number should be converted to a percentage. In the example cited, 13 is 36.1% of the total 36 evaluations made for Treatment A.

C. All treatments, all judges:

1. Determine the range of the total scores for each treatment that were computed for B-1 above. In Table 1 this value is 142 which is obtained by subtracting 49 (sum for Treatment C) from 191, the sum for Treatment B. Enter this figure on the summary tabulation form on the lower right hand at the base of the Total Column.

2. Obtain the judge total by adding the *range of judge sums* for each treatment. In the example cited, the 3 ranges are 15 for A, 14 for B, and 8 for C, making a total of 37. This figure should be entered at the base of the column headed Range of Judge Sums.

3. The next step is to determine the overall significant difference (O.S.D.) values to determine whether any significant differences exist among treatments. To do this, obtain the appropriate factors from Table 3. These factors are found in Table 3 in the column for the number of treatments that were used and on the line for the number of judges. In the example used, the appropriate factors are found in column 3, "for number of treatments" and on line 9, "for number of judges." For significance at the 5% level, the figure is 1.18, and at the 1% level, 1.53. Multiply this factor by the judge range total, 37. This will give 43.7 at the 5% level and 56.6 at the 1% level. In the example, Table 1, the grand range of totals is 142 which greatly exceeds the O.S.D. value of 56.6, and, therefore, a highly significant difference among treatments exists.

4. The next step is to determine the least significant difference (L.S.D.) values which will permit an evaluation of differences between any two treatments. It is necessary, however, that the O.S.D. value be significant before L.S.D. values are calculated and specific comparisons between treatments are made. (To be significant the O.S.D. value at the 5% level of

TABLE 1

Example (Laboratory 4): Summary of flavor difference scores

NOTE: Place an asterisk next to sample score when sample flavor was judged not acceptable.

Test code, Tomato juice
Dates of test, 1955

Treatment	Replicate	Flavor difference scores for indicated judge																				Total	Range of judge sums	No. not acceptable
		1	2	3[1]	4	5	6[1]	7	8[1]	9	10	11	12[1]	13	14[1]	15[1]	16	17	18	19	20			
A Code 19225	I	2	5*	*2*	3	7*	*7**	3	*1*	1	4	5*	*3*	6*	*5**	*3*								
	II	3	1	*2*	2	6*	*3*	3	*3*	3	3	3	*1*	9*	*3*	*1*								
	III	4	7	*2*	3	4*	*5*	7*	*1*	2	3	3*	*2*	7*	*2*	*1*								
	IV	3	6*	*2*	3	4*	*7**	5*	*1*	2	2	1	*1*	1	*2*	*3*								
	Sum	12	19	*8*	11	21	*22*	18	*6*	8	13	12	*7*	23	*12*	*8*						136	15	13
	Range	2	6	*0*	1	3	*4*	4	*2*	2	2	4	*2*	8	*3*	*2*						Per cent not acceptable = 36.1		
B Code 29225	I	2	5*	*4*	3	5*	*5**	7*	*1*	6*	3	7*	*3*	6*	7*	*1*								
	II	5*	5*	*5**	3	5*	*3*	7*	*1*	6*	7*	5*	*3*	6*	*5**	*3*								
	III	6*	9*	*1*	5	6*	*5**	5*	*3*	5*	5*	3*	*1*	7*	*1*	*1*								
	IV	5	9*	*4**	3	6*	*5**	7*	*1*	5*	2	3*	*2*	7*	*2*	*5**								
	Sum	18	28	*14*	14	22	*18*	26	*6*	22	17	18	*9*	26	*15*	*10*						191	14	28
	Range	4	4	*4*	2	1	*2*	2	*2*	1	5	4	*2*	1	*6*	*4*						Per cent not acceptable = 77.8		
C Control 09225	I	2	1	*3*	3	1	*3*	1	*1*	5	1	1	*1*	1	*3*	*1*								
	II	1	1	*1*	2	1	*6**	1	*1*	3	1	1	*1*	1	*3*	*1*								
	III	2	1	*2*	1	1	*3*	1	*3*	2	1	1	*1*	1	*3*	*1*								
	IV	1	1	*4**	1	1	*3**	1	*4*	2	1	1	*1*	1	*1*	*1*								
	Sum	6	4	*10*	7	4	*17*	4	*9*	12	4	4	*4*	4	*10*	*4*						49	8	0
	Range	1	0	*3*	2	0	*3*	0	*3*	3	0	0	*0*	0	*2*	*0*						Per cent not acceptable = 0		
Grand sum of ranges		7	10	7	5	4	*9*	6	7	6	7	8	*4*	9	*11*	*6*							37	← Judge range Total
Grand range of sums		12	24	*6*	7	18	*3*	22	*3*	14	13	14	*3*	22	*5*	*6*						142		
O.S.D. (1.25)		8.8	12.5	*8.8*	6.3	5.0	*11.3*	7.5	*8.8*	7.5	8.8	10.0	*5.0*	11.3	*13.8*	*7.5*						↑ Grand range of totals		

[1] These judges (3, 6, 8, 12, 14, 15) were unable to distinguish flavor differences and their data (in italics) were eliminated from consideration.

TABLE 2

Code numbers to be assigned each treatment[1] in each replicate

Replicate	Treatments								
	A	B	C	D	E	F	G	H	I
I	14	15	16	19	17	18	11	12	13
II	23	21	22	26	24	25	29	27	28
III	32	33	31	35	36	34	38	39	37
IV	47	48	49	41	42	43	44	45	46
V	59	57	58	53	51	52	56	54	55
VI	68	69	67	62	63	61	65	66	64

[1] The same first digit has been assigned each treatment in the same replicate to aid the supervisor in identifying replicates and thus avoid transcription errors.

Each treatment has been assigned a different second digit in each replicate to prevent judges from associating numbers with treatments.

significance must be less than the grand range of totals.) The procedure for calculating L.S.D. values is essentially identical to that used for O.S.D. In the example, the judge range total, 37, is multiplied by the L.S.D. factor found in Table 4 in the column headed 3 (number of treatments) and on line 9 (number of judges). The L.S.D. value at the 5% level is $.98 \times 37 = 36.3$; at the 1% level it is $1.34 \times 37 = 49.6$. Therefore, the differences between any two treatment totals ($A - C = 87$, $B - C = 142$, and $B - A = 55$) are significant at the 1% level in this illustration.

D. Determining the significance of the percentage not acceptable:

Table 5 contains the minimum percentage not ac-

TABLE 3

Multipliers of the range for computing over-all significant difference (O. S. D.) in evaluating judge performance and treatment differences when using the simplified flavor difference procedure

Number of judges or replicates	Number of treatments and Significance Level															
	2		3		4		5		6		7		8		9	
	5%	1%	5%	1%	5%	1%	5%	1%	5%	1%	5%	1%	5%	1%	5%	1%
	Multipliers															
2	3.43	7.92	2.37	4.42	1.78	2.96	1.40	2.06	1.16	1.69	1.00	1.39	.87	1.20	.78	1.03
3	1.91	3.14	1.44	2.14	1.13	1.57	.94	1.25	.80	1.04	.70	.89	.62	.78	.56	.69
4	1.63	2.47	1.25	1.74	1.01	1.33	.84	1.08	.73	.91	.63	.78	.57	.69	.51	.62
5	1.53	2.24	1.19	1.60	.96	1.24	.81	1.02	.70	.86	.61	.75	.55	.66	.50	.59
6	1.50	2.14	1.18	1.55	.95	1.21	.80	.99	.69	.85	.61	.74	.55	.65	.49	.59
7	1.49	2.10	1.17	1.53	.95	1.21	.80	.99	.69	.84	.61	.74	.55	.65	.50	.59
8	1.49	2.08	1.17	1.52	.96	1.21	.81	.99	.70	.85	.62	.74	.55	.66	.50	.59
9	1.50	2.09	1.18	1.53	.97	1.22	.82	1.00	.71	.85	.62	.75	.56	.66	.51	.60
10	1.52	2.10	1.20	1.55	.98	1.23	.83	1.01	.72	.86	.63	.75	.57	.67	.52	.61
11	1.54	2.11	1.21	1.56	.99	1.24	.84	1.02	.73	.88	.64	.77	.58	.68	.52	.61
12	1.56	2.13	1.23	1.58	1.00	1.25	.85	1.03	.74	.89	.65	.78	.59	.69	.53	.62
13	1.58	2.15	1.25	1.60	1.02	1.27	.86	1.05	.75	.90	.66	.79	.59	.70	.54	.63
14	1.60	2.18	1.26	1.62	1.03	1.28	.87	1.06	.76	.91	.67	.80	.60	.71	.55	.64
15	1.62	2.20	1.28	1.64	1.05	1.30	.89	1.08	.77	.92	.68	.81	.61	.72	.56	.65
16	1.64	2.22	1.30	1.65	1.06	1.31	.90	1.09	.78	.93	.69	.82	.62	.73	.56	.66
17	1.66	2.24	1.31	1.67	1.08	1.33	.91	1.11	.79	.95	.70	.83	.63	.74	.57	.67
18	1.68	2.27	1.33	1.69	1.09	1.34	.92	1.12	.80	.96	.71	.84	.64	.75	.58	.68
19	1.70	2.30	1.34	1.71	1.10	1.36	.93	1.14	.81	.97	.72	.85	.65	.76	.59	.68
20	1.72	2.32	1.36	1.73	1.11	1.38	.93	1.15	.82	.98	.73	.86	.65	.77	.59	.69

This table, shortened from tables prepared by Thomas E. Kurtz, Richard F. Link, John W. Tukey, and David L. Wallace. (2)

TABLE 4

Multipliers of the range for computing the least significant difference (L. S. D.) in evaluating judge performance and treatment differences when using the simplified flavor difference procedure

Number of judges or replicates	Number of treatments and Significance Level															
	2		3		4		5		6		7		8		9	
	5%	1%	5%	1%	5%	1%	5%	1%	5%	1%	5%	1%	5%	1%	5%	1%
	Multipliers															
2	3.43	7.92	1.76	3.35	1.18	1.96	.88	.39	.70	1.07	.58	.87	.50	.74	.44	.63
3	1.63	3.14	1.14	1.73	.81	1.19	.63	.91	.52	.73	.44	.61	.38	.53	.33	.46
4	1.91	2.47	1.02	1.47	.74	1.04	.58	.80	.48	.68	.40	.55	.35	.48	.31	.44
5	1.53	2.24	.98	1.37	.72	.98	.56	.77	.47	.63	.40	.54	.34	.47	.30	.43
6	1.50	2.14	.96	1.32	.71	.96	.56	.76	.46	.62	.40	.53	.34	.46	.30	.42
7	1.49	2.10	.96	1.33	.71	.96	.56	.76	.47	.63	.40	.53	.35	.46	.31	.42
8	1.49	2.08	.97	1.33	.72	.97	.57	.77	.47	.63	.41	.54	.35	.47	.31	.42
9	1.50	2.09	.98	1.34	.73	.98	.58	.77	.48	.64	.41	.55	.36	.48	.31	.43
10	1.52	2.10	.99	1.35	.74	.99	.59	.78	.49	.65	.42	.55	.37	.48	.32	.43
11	1.54	2.11	1.00	1.35	.74	.99	.59	.79	.49	.65	.42	.56	.37	.49	.32	.43
12	1.56	2.13	1.01	1.36	.75	1.00	.60	.80	.50	.67	.43	.57	.38	.50	.33	.44
13	1.58	2.15	1.03	1.38	.76	1.01	.61	.81	.51	.68	.43	.57	.38	.50	.34	.45
14	1.60	2.18	1.04	1.39	.77	1.03	.62	.82	.52	.69	.44	.58	.38	.50	.34	.45
15	1.62	2.20	1.06	1.42	.79	1.05	.63	.84	.52	.69	.45	.60	.39	.52	.35	.46
16	1.64	2.22	1.07	1.43	.80	1.07	.64	.85	.53	.70	.45	.60	.40	.53	.35	.46
17	1.66	2.24	1.08	1.44	.81	1.08	.65	.86	.54	.72	.46	.61	.40	.53	.36	.48
18	1.68	2.27	1.10	1.46	.82	1.09	.65	.86	.54	.72	.47	.62	.41	.54	.36	.48
19	1.70	2.30	1.11	1.48	.83	1.10	.66	.88	.55	.73	.47	.62	.42	.56	.37	.49
20	1.72	2.32	1.13	1.51	.83	1.10	.67	.89	.56	.74	.48	.64	.42	.56	.37	.49

Extension of table prepared by J. W. Tukey. (3)
Factors for 11 to 20 replicates calculated by H. L. Stier.

TABLE 5

Minimum percentage of "not acceptable" required for significance at the 1% level

Number judgments	20	25	30	31	32	33	34	35	40
Minimum per cent	31.8	26.5	23.5	23.0	22.0	21.5	21.0	20.5	18.5

Number judgments	45	50	55	60	65	70	75	80
Minimum per cent	17.0	15.5	14.5	13.5	12.5	11.5	11.0	10.5

ceptable that is necessary for significance at the 1% level for the indicated number of flavor difference evaluations. For example, with the 36 flavor difference evaluations used in this illustration, a minimum percentage of 20.5 is needed for significance. Hence, the percentages rated not acceptable in both Treatments A and B (36.1 and 77.8) are highly significant.

LITERATURE CITED

1. KRAMER, AMIHUD, AND DITMAN, L. P. A simplified variables taste panel method for detecting flavor changes in vegetables treated with pesticides. *Food Technol.*, 10, 155-159 (1956).
2. KURTZ, T. E., LINK, R. F., TUKEY, J. W., AND WALLACE, D. L. Short analyses for balanced single and double classifications. *Trans., N. Y. Acad. Sci.* Ser. II. 16(2), 97 (1953).
3. TUKEY, JOHN W. Quick and dirty methods in statistics. II. Simple analysis for standard designs. Quality Control Conf. Papers. Amer. Soc. Qual. Control. pp. 189-199 (1951).
4. TUKEY, JOHN W. Quick and easy comparisons. (1953 Version) Multilith — 10 pages.
5. TUKEY, JOHN W. Some selected quick and easy methods of statistical analysis. *Trans.* N. Y. Acad. Sci. Ser. II. 16(2), 88-97 (1953).

The Northeast Regional Approach to Collaborative Panel Testing

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Agricultural Experiment Stations

Connecticut — Massachusetts
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THE NORTHEAST REGIONAL PROJECT 15 (NE 15) was organized in 1954, in response to industry concern about the possible deleterious effects of commonly used pesticides on the flavor of fresh and processed fruits and vegetables. Food technologists, horticulturists, entomologists, plant pathologists and home economists from the agricultural experiment stations of Connecticut, Maine, Maryland, Massachusetts, New Jersey, New York, and Pennsylvania combined their efforts in an active program whose general objectives were (a) to develop a standard and uniform method to evaluate flavor differences, (b) to determine the effects of certain pesticides on the flavor of selected fruits and vegetables. This report deals primarily with the first objective.

A review of panel testing literature and procedures used at the various experiment stations was conducted for the purpose of selecting a simple efficient method showing the greatest precision and accuracy. It was intended that the procedure selected would be used as a laboratory tool, not as a substitute for consumer acceptance testing. After considerable study, it was decided to investigate under regional or collaborative conditions a multiple comparison method, scoring against descriptive terms, since modifications of this method were already in use by some of the NE 15 agricultural experiment stations. At the same time another group, the National Canners Association and their cooperators *(2, 6)*, were carefully investigating the triangular or modified triple comparison method.

Briefly, the over-all NE 15 procedure calls for careful selection of field treated fruit and vegetable crops, uniform processing, selection of competent judges,

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replicated evaluations of test materials, and standard procedures for the analysis and interpretation of results.

DEVELOPMENT OF THE NE 15 PROCEDURE

Selection of test materials and crops. Fruit and vegetable products subjected to flavor evaluations were chemically treated in 3 ways: (a) crops were treated with concentrations of chemicals assuring definite flavor changes. (b) crops were treated with concentrations of chemicals at levels recommended for commercial field operations, (c) crops were treated with a minimum of chemicals or were entirely untreated. With some crops it was impossible to produce a usable product without at least a fungicide treatment. Chemicals tested thus far by the NE 15 group are those recommended for use on certain crops and those which have been known in some cases to cause flavor differences.

It is essential to have complete information regarding the handling and growing of raw materials to have valid results. The check sheet shown in Figure 1 (prepared by the Maine Experiment Station) will be adopted in the 1957 testing season to collect this important background information. This information will be supplied by the station producing the raw crop and carbon copies will be sent to the stations participating in the actual flavor evaluation.

Sample preparation and processing. Whether the product was canned or frozen, it was of the utmost importance that processing preparation and cooking be standardized at all locations since over-processing or improper handling procedures could easily overshadow any pesticidal changes in the flavor of the foods. Where possible commercial canning and freezing procedures were used, following in the case of canning the recommended N.C.A. processing times and temperatures *(7)*. In Figure 2 is shown the recently developed harvesting and processing check sheet which will be used for commodities processed in the 1957 season. Use of this sheet will facilitate the interpretation of results. It will be prepared by the processing station with carbon copies for each of the stations conducting the taste panels.

In this 2-year study uniform processed samples of squash and apple sauce have been distributed among the 5 experiment stations for comparable evaluation or collaborative testing. In addition canned and frozen peaches have been tested at 3 stations, frozen apple juice at 3, and broccoli at one station. Additional crops have been tested by individual stations. Further details concerning these tests are found in an earlier paper *(9)*.

Selection of a scoring sheet and grading scale. The scoring sheet and grading scale were modified somewhat during the 2-year investigation. Some of the details considered in reaching the presently used scoring sheet are as follows:

1. Is it simple, short, and understandable to the judge?
2. Can clear-cut decisions be made by the judge?
3. Does it actually get the information desired?
4. Is the investigator able to easily assemble record forms for testing and then quickly tabulate results?

Figure 3 shows the score sheet used by the NE 15 collaborators. The judge, in evaluating the sample, graded against a series of descriptive terms and was supplied a standard reference sample which was also included unmarked in the test. These descriptive terms were assigned the values shown in parenthesis at the bottom of Figure 3. Although in the past we have used the two sets of values interchangeably, we have recently decided to use only the + and − set of figures.

In developing the 5-point scale for measuring pesticidal flavor differences, it was recognized that pesticide application to fruits and vegetables may in some cases improve the flavor of the processed product. This phenomenon may be due to insect and disease control which in turn results in more vigorous and healthy plants. For this reason a *better-than-standard* category was included in the 5-point scale. The other categories are self explanatory except, possibly, for the grouping designated as *below-standard-in-flavor, no-detectable-off-flavor*. This point was added to the scale because in some

Code_____

Commodity_____

Date_____

1. Soil:
   Type: _____
   pH: _____
2. Fertilizer:
   Based on Soil Analysis? Yes ____ No____ Attach data
   Kind: _____
   Amount: _____
   Application method: _____
   Application rate: _____
   Application date: _____
3. Insecticides:
   Kind: _____
   Amount: _____
   Application method: _____
   Application rate: _____
   Application dates: _____
4. Fungicides: _____
   Kind: _____
   Amount: _____
   Application method: _____
   Application rate: _____
   Application dates: _____
5. Herbicides:
   Kind: _____
   Amount: _____
   Application method: _____
   Application rate: _____
   Application dates: _____
6. Soil history: _____
   Were pesticides applied in previous years?____. If so:
   Kind: _____
   Amounts: _____
   Years: _____
7. Planting Data:
   Where grown: _____
   Design: _____
   No. of reps: _____
   Method of seeding: _____
   Planting date: _____
   Harvest date: _____
8. Miscellaneous Information:

Figure 1. Check sheet for cultural and chemical treatments used on products for NE 15 collaborative panel testing.

cases it was considered that the samples tested were not equal to standard nor were they slightly off flavor. Hence, a neutral category was needed.

Further, the 5-point scale with a difference of 1 point between categories was believed to be indicative of practical or commercially significant differences among samples.

At the bottom of Figure 3 are words descriptive of flavor but used only to describe off flavors. These descriptions aid in recognizing similar types of off flavor reported in other products by identical pesticides and also in reporting research in technical publications.

Selection of judges. Judges were selected, using the scores obtained with treated and untreated samples of the chemicals and crops outlined previously as criteria. In an earlier report by Wiley *et al. (9)* a large number of judges were screened twice, in the first screening each treatment of the product was tasted 4 times. Judge's individual scores were set up in a balanced factorial design and then studied by analysis of variance. Those judges showing statistical significance for treatment at odds of 9:1 were retained for further testing. In a second screening, the retained judges retested the product, replicating 4 times, and were dropped from the panel if their F values for treatment were not significant at odds of 19:1. Finally, the remaining group of selected judges retested the product 4 times; their evaluations were used to determine the magnitude of differences among treatments.

By using this screening method, if no real differences were evident among treatments, the final group of selected judges

Code _____ Date _____

Commodity _____

1. Stage of maturity or development at harvest
   - Fancy _____
   - X Standard _____
   - Standard _____
   - Sub-Standard _____

	day	hour
2. Date harvested		
Date processed		

3. Processing techniques

	canning	freezing
Blanching times		
Processing time-temp.		
SPECIAL TECHNIQUES		
Pulping		
Pressing		
Filtering		
Dicing		
Enzymatic treament		
Other		

4. Can or frozen package information
   - Size _____
   - Lining _____
   - Overwrap _____
5. Packaging media
   - Salt % _____
   - Sugar % _____
   - Spices _____
   - Other _____

Measure by objective means if possible

Immature _____	Green _____
Nearly mature _____	Firm Ripe _____
Mature _____	Ripe _____
Over mature _____	Overripe _____

COMMENTS

1. Were there any noticeable differences in test samples due to:
   - a. Color _____
   - b. Texture _____
   - c. Appearance _____
   - d. Other _____
2. Is there any possible way you think samples may be different in flavor except from the addition of pesticides in the field?
3. Miscellaneous information

INSTRUCTIONS

1. Fill in only information you feel is pertinent to the samples in question.
2. If all samples of a commodity are processed in one day, only one sheet should be filled out for the samples but if different days and times are involved a sheet should be filled out each time.

Figure 2. Check sheet for harvesting and processing products for NE 15 collaborative panel testing.

would be extremely small — probably indicating that no further testing was necessary. If there were significant differences between the samples, however, the person conducting the screening would be able to rank a considerable number of workers by their F values for treatments and take only the top 10 or 12 individuals. The higher the F value for treatment, the more acute the judge. In the same work *(9)* it was found that a panel of 10 to 12 judges was slightly more efficient than either a large unscreened group of judges (25 to 45) or an extremely small (3 to 5) panel of trained experts.

Another screening method, suggested by Kramer and Ditman (4), has been used by the collaborators. In this procedure a large group of judges was asked to taste a set of samples replicated 3 or 4 times. Scores were placed on data sheets and the judges were ranked, using the analysis from the range.

Typical ranking calculations are shown in Table 1. In this set of test materials Judge 1 ranked as most efficient because he showed considerable differences among treatments and was able also to duplicate his results in most replications. Judge 2 showed very little difference between treatments and, furthermore, was not consistent in repeating his evaluation on duplicated samples. In consideration of these various factors, the method was based on the criterion that judges with small differences between replications but with great acuity in picking out differences between treatments should be retained, whereas judges showing great replication differences should be dropped from the panel.

Evaluation of samples. All of the uniform testing conditions and standard environs suggested by Boggs and Hanson *(1)* were followed in evaluating the test commodities.

Samples were presented to 10 to 12 selected ranked judges. Using the evaluation sheet (Fig. 3) the judges scored the samples against a marked standard or reference sample, sometimes evaluating as many as 10 samples at one sitting. Generally, the requirements of the NE 15 group have been to replicate tastings 4 times, however, a minimum of 40 judgments (10 judges × 4 replications) has been set as a basis for securing taste panel results. Replication was allowed with a half-hour break between samplings but were generally set up on a two-day basis with panels in the morning and afternoon of two successive days at about 10:30 a.m. and 2:30 p.m.

Tabulation of results. Results were tabulated directly into an analysis of variance table. Some results from canned green beans grown on irrigated and non-irrigated plots, sprayed with various pesticides and including a control, are shown in Table 2.

INTERPRETATION OF RESULTS

From these data (Table 2) let us consider that each of the upper two blocks contain the score of one evaluation. In our collaborative efforts the mean or total of 3 or 4 judgments was placed in the appropriate box. From the analysis we may determine whether or not there was significance among treatments, judges, and soil moisture and whether or not there was a Treatment × Judge interaction. If this interaction were present, it would mean that some judges graded treated samples at the upper end of the scale while others may have graded the same sample at the lower end. Thus, this pesticide may be affecting certain judges adversely whereas others felt no response one way or the other.

Treatment 1, significantly higher than control in flavor, fell into the equal-to-standard category. Treatment 2, significantly lower than control in flavor, fell in the slightly-off-flavor grouping. The rather low rating for the control sample was probably due to extreme insect and disease damage to the growing crop. Judges were significantly different with respect to the way they graded the samples. Judge significance was a common problem, in fact, but it was not as prevalent in a homogeneous food such as apple sauce as in others. It occurred frequently in the evaluation of squash, broccoli, and green beans. There was no significant difference between samples from plots of different soil moistures.

By using Duncan's method *(3)* or Snedecor's L.S.D. calculation *(8)*, one may determine the significant differences among means for treatments, judges, and moistures.

Rate **Flavor** only. Ignore all other Differences

Name _____ Project Code _____

Date _____ Product _____

CHECK ONE:

Sample	Better than standard in flavor	Equal to standard in flavor	Below standard in flavor, no detectable off-flavor	Slightly off-flavor	Definitely off-flavor not acceptable	Describe off-flavor[1] if possible
1						
2						
3						
4						
5						
6						
7						
8						
9						
10	(5 / +2	4 / +1	3 / 0	2 / −1	1 / −2)	

[1] List of suggested words:

Bitter, Burnt, Earthy, Flat, Fragrant, Medicinal, Metallic, Musty, Oily, Putrid, Puckery, Rancid, Salty, Sour, Spicy, Sweet, Woody

Figure 3. The NE 15 flavor evaluation form.

Measurement of panel efficiency. Panel efficiency was measured in terms of number of individual tastings required for demonstrating statistical significance at the 1% level. This was accomplished by use of "Sample Number Ratio" (SNR) *(5)*, multiplied by the number of tastings used (N). SNR may be obtained by the following equation:

$$\text{SNR} = \left(\frac{\text{LSD 1\% for treatment means}}{\text{Range for treatments}} \right)^2$$

The LSD 1% was the calculated least significant difference at the 1% level. The range was determined by substracting the smallest mean treatment value from the highest. The number of tastings required for demonstrating significance may then be obtained by multiplying the SNR × N where N = the number of tastings actually used in the test.

The efficiency of the panel in

$$\text{Table 2} = \left(\frac{\text{LSD 1\%}}{\text{Range}} \right)^2 = \left(\frac{.78}{2.00} \right)^2 = .15$$

with .15 × N (70) = 10.5 or 11 tastings. In other words this same group with identical samples could have obtained the same significant results with a minimum of 11 tastings.

In comparing the efficiency of the panel from

TABLE 1

Typical data[1] showing ranking of judges using analysis from the range technique

Treatments	Judge 1 Replications					Judge 2 Replications					Judge 3 Replications					Judge 4 Replications				
	1	2	3	4	Total	1	2	3	4	Total	1	2	3	4	Total	1	2	3	4	Total
1	4	3	4	4	15	4	1	2	4	11	3	3	4	5	15	3	3	1	5	12
2	1	1	2	1	5	3	5	1	3	12	2	4	4	3	12	3	2	4	4	13
3	1	1	1	1	4	4	4	3	4	15	1	1	1	3	5	1	3	4	2	10
4	5	4	4	5	19	1	1	4	4	10	1	4	3	1	9	1	1	1	2	5
5	5	5	4	5	19	2	2	5	5	14	1	1	1	2	5	5	5	2	2	14
Range among samples. Difference between largest and smallest treatment total					15					3					10					9
Range between replications. Sum of difference between Rep. 1, 2, 3, and 4					4					14					10					13
Ratio: range among samples / total range among replications					4.15					.214					1.00					.692
Rank of judges					1					4					2					3

[1] Convert to + or − scale by subtracting 3 from each judge's score.

TABLE 2
Example of handling experimental data[1] from the scoring sheets
Green Beans

	Treatments	Judges A	B	C	D	E	F	G	Totals	Treatment mean
Irrigated	1	4	5	4	4	5	4	3	29	4.14
	2	2	2	1	3	1	3	2	14	2.00
	3	4	3	3	4	3	4	3	24	3.43
	4	4	3	4	4	4	4	3	26	3.71
	5 control	3	3	3	3	2	4	2	20	2.86
	TOTALS	17	16	15	18	15	19	13	113	
Not irrigated	1	4	4	4	3	5	4	3	27	3.86
	2	1	3	2	1	1	5	1	14	2.00
	3	4	3	4	4	3	4	3	23	3.29
	4	4	3	3	4	3	4	3	24	3.43
	5 control	3	3	4	3	2	4	2	21	3.00
	TOTALS	16	15	17	15	13	21	12	109	
	Combined Totals 1	8	9	8	7	10	8	6	56	4.00** > control
	2	3	5	3	4	2	8	3	28	2.00** < control
	3	8	5	7	8	5	8	6	47	3.36
	4	8	6	7	8	7	8	6	50	3.57
	5 control	6	6	7	6	4	8	4	41	2.92
	TOTALS	33	31	32	33	28	40	25	222	LSD 1% = .78

Analysis of variance

Source of variance	d/f	Sum sq.	Variance	F
Treatment	4	32	8.00	27.58**
Judge	6	13	2.17	7.48**
Soil measure	1	0		n.s.
T X J	24	19	.79	2.72**
Error	34	10	.29	
Total	69	74		

[1] Convert to + or − scale by subtracting 3 from each judge's score.
** Significant at the 1% level.

Table 2 with the panel of Table 3, it is readily seen that the first panel was much more efficient than the second. Evaluation of this test material could be accomplished by Panel No. 1 with fewer members and replications while Panel No. 2 would require more replications or judges to get significant results.

After ranking the various panels in a collaborative study by commodity and test material, it was also important to determine whether or not results were on a practical basis. We have used the term "Least Practical Difference" (LPD) *(5)* to indicate differences of practical magnitude in contrast to the LSD term which indicates differences that were statistically significant but not necessarily of practical importance. For example, if an investigator using Panel No. 1 decided that a unit difference on the flavor scale was of practical magnitude the LPD would be 1.0. The following formula was used to give a suitable basis for setting the number of tastings required for obtaining practical significance at this level:

$$N \text{ required} = \left(\frac{\text{LSD 1\% for treatment}}{\text{LPD}}\right)^2 \times N \text{ used}$$

In data from Table 2 the LSD 1% was .78 and let us say our LPD would be 1.0. Seventy tastings were used. Then, the N required $= \left(\frac{.78}{1.00}\right)^2 \times 70$, or 43 tastings required for an LPD of 1.0. Hence, only 43 tastings would have been required to get a practical difference of 1.0 on the flavor scale.

In Panel No. 2, since the LSD was already over 1.0 N required $= \left(\frac{1.1}{1.0}\right)$, $\times$ 70 or 85 tastings are required for a LPD of 1.0. It was also agreed where the LPD could not be obtained with a maximum of 40 judgments per sample a practical difference did not exist.

TABLE 3
Mean values[1] for treatments of Panel 2 testing irrigated and non-irrigated canned green beans

Panel No. 2	
1.	3.80
2.	3.10
3.	3.40
4.	3.35
5.	3.40
LSD 1%	1.10
Range	.70

$$SNR = \left(\frac{\text{LSD 1\%}}{\text{Range}}\right)^2 = \left(\frac{1.10}{.70}\right)^2 = 2.46$$

$$2.46 \times 70 = 172$$

[1] Convert to + or − scale by subtracting 3 from each mean value.

Panel agreement. The panel agreement among the 5 agricultural experiment stations using this method are remarkably uniform. These results are fully covered in an earlier paper using this method *(9)*.

WORKING MODEL OF THE NE 15 PROCEDURE

I. Panel of unknown efficiency or wholly untrained persons.

1. With the largest number of people available, using an evaluation form similar to Figure 3, present all treatments (up to 10) in a random fashion replicating 4 times. This test should be conducted at 4 different sittings.
2. Assign numbers to evaluations and set up individual judge scores in an analysis of variance table.
3. Use analysis of variance on individual judges scores.
4. If treatment F values are not significant and SNR × N values are very high, there is little likelihood of any real difference between samples. Testing can be discontinued.
5. If treatment F values are significant, further testing is required. Rank judges by individual F values for treatment or by the analysis from range, quick method *(4)*.
6. Calculate SNR × N determined from the untested panel performance.
7. Using this as a guide, allow selected 10 to 12 judges to evaluate the product the required number of tastings. Generally there should be a minimum of 40 tastings per sample.
8. Analyze results of No. 7 by analysis of variance to determine magnitude of differences between samples.
9. For collaborative studies the data from at least two laboratories should be combined because of consistent treatment × location interactions in past results.
10. If the differences indicated by the LSD are not of practical magnitude on the scale used, an investigator may wish to determine the number of tastings required for a practical difference (LPD) which could be used for reducing future work with similar panels.

II. Panel of known efficiency or of trained persons.

1. Use 10 to 12 selected persons for evaluating samples. Use form similar to Figure 3.
2. As a guide for number of replications to present judges, use the SNR × N from past performances. There should be a minimum of 40 tastings per sample.
3. Analyze results of No. 2 by analysis of variance.
4. Same as I—9.
5. Same as I—10.

III. Panels which show significant interaction between treatments and judges.

1. If selected or untested panels show repeatedly significant interaction between treatments and judges, the samples if possible should be presented to a large consumer panel for further testing.

ADVANTAGES AND DISADVANTAGES OF THE NORTHEAST REGIONAL 15 METHOD

Advantages

1. The standard method or procedure is simple and workable on a regional or collaborative basis.
2. Screening techniques can be used in conjunction with training of judges.
3. Descriptive words to describe off flavors will assist workers in the field in recognizing flavors associated with certain pesticides.
4. Panel efficiency can be quickly measured.
5. Standard statistical techniques are applicable to obtain information from the data from the individual laboratories as well as from a combination of several laboratories.
6. There is unusually good agreement among the laboratories in the way they score the samples.
7. Results can be reported in meaningful terms, for example:
   1 = definitely off flavor
   5 = better than standard in flavor.
8. Complex factors which affect flavor can be studied with a minimum number of panels and minimum amount of test material.

Disadvantages and limitations

1. The standard or reference sample is difficult to maintain and does not always fall at its designated point on the evaluation scale.
2. The number of judges (10 to 12) for best results may limit this method to larger stations or laboratories where adequate personnel are available.
3. There may be little agreement in the way individual judges use the descriptive words to describe off flavors. As a result, it is difficult to ascertain exactly the reaction of the panel to a definitely off flavored sample.

LITERATURE CITED

1. Boggs, Mildred M., and Hanson, Helen L. Analysis of foods by sensory difference tests in *Advances in Food Research*, 2, 219-258 (1949).
2. Briant, Alice M., Gould, Wilbur A., Hening, J. C., Henreiner, E., Kramer, A., MacLinn, W. A., Ross, E., Sather, L., Tompkins, M., and Weckel, K. Studies leading to the development of a "Standardized Procedure" for making flavor evaluations of canned foods treated with chemical pesticides. *Food Technol.*, 8, *Abstracts of Annual Meeting Papers* (May, 1954).
3. Duncan, David B. Multiple range and multiple F tests. *Biometrics*, 2, 1-42 (1955).
4. Kramer, A., and Ditman, L. P. A simplified variables taste panel method for detecting flavor changes in vegetables. treated with pesticides. *Food Technol.*, 10, 155-159 (1956).
5. Kramer, A., and Wiley, Robert C. (Unpublished data. Maryland Agricultural Experiment Station, 1956).
6. Mahoney, C. H., Stier, H. L., and Crosby, E. L. Evaluation of flavor differences in canned foods due to the applications of pesticides to the processing crop. Parts I and II. *Food Technol.*, 11, 32, *Abstracts of Annual Meeting Papers*, (April, 1957).
7. National Canners Association. *Bulletin 26L*, 8th ed. (1955).
8. Snedecor, George W. *Statistical Methods*. 1946. The Iowa State College Press, Ames, Iowa.
9. Wiley, Robert C., Briant, Alice M., Ferguson, Irving S., Murphy, Elizabeth F., and Sabry, Jean H. Evaluation of flavor changes due to pesticides. A regional approach. *Food Research*, 22, 192 (1957).

Time-Temperature Tolerance

Continued from page 472

In order to check the reproducibility of results over a period of time, control samples were stored at 20° F. after 0, 3, 6, and 12 months of storage at −20° F. Other samples were stored at 15° F. after 0, 6, 12, and 18 months at −20° F.

Organoleptic evaluation. Samples were evaluated for color and flavor by the triangle test. The tests were conducted in individual booths—color under standard daylight lamps and flavor under subdued lighting so as to eliminate any possible color differences. Many of the tests were conducted with 5 highly trained judges who exhibited a high degree of sensitivity to deteriorative changes. Each of these tests was replicated 4 times giving a total of 20 judgments. Other tests were conducted with larger panels (10-15 judges) and these tests were replicated two to three times. Each judge evaluated two sets of triangles at one sitting. Examination of the results obtained with over 19,000 individual triangles showed that the percentage of correct responses in the first triangle as compared to the second was essentially equal, thus indicating no difference in acuity between first and second triangles.

Probability values for the triangle data were obtained from the Tables of the Binomial Probability Distribution *(3)*.

RESULTS AND DISCUSSION

Value of the time-response curve. Figure 1 shows a typical example of the fluctuation in percentage of correct answers in a sample of commercially packed frozen raspberries stored at 15° F. It is of particular interest that no consistent increase in percentage of correct answers was observed until the sample was stored for at least 3 weeks. However, it is also pertinent to note that a significant difference at a probability level of .03 was observed after as little as 8 and 9 days of storage. In view of the results obtained during subsequent tests it is clear that if the experiment had been terminated on the basis of the 8-day results, a two-to three-fold error in the time required for a real deteriorative change would have resulted. A plot of correct answers versus storage time not only indicates the point at which a consistent increase of correct answers is observed, thus guarding against erroneous decisions, but also allows for comparison of the time required to reach various probability levels. Furthermore, comparisons between samples or temperatures may be made at percentages of correct responses corresponding to a wide range of probability levels. In certain instances where the difference in rate of change between two temperatures is relatively small or where factors other than deterioration are contributing to the correct segregation of samples, it is often advantageous to compare samples or temperatures at a higher percentage of correct responses or a lower probability level. As the probability level is lowered, we are more certain that the difference between samples is real and due to the deteriorative changes brought about by differences in storage temperature rather than other extraneous factors. An example of this may be taken from the data obtained on frozen strawberries: only 13 days were required at both 10 and 15° F. for 55 to 60% correct flavor judgments (P = .05 to .01). If this probability level were accepted as representing a deteriorative change we might conclude that there was little or no temperature effect in this range. However, examination of ascorbic acid changes in samples stored at 10°F. and 15° F. for 13 days indicated an average loss of 3 and 14% respectively. This definitely shows a temperature effect, and that 13 days at 10° F. does not equal 13 days at 15° F. as might be assumed from the taste results at a probability level of .05 to .01. On the other hand, if the requirement for correct judgments is raised to 70-80% (much lower probability level) it takes approximately 56 and 24 days to reach this level of significance at 10° and 15° F. respectively. The ascorbic acid losses at these times and temperatures were 22 and 25% respectively. This indicates that approximately the same amount of ascorbic acid was lost under these two conditions, and therefore it is far more logical to accept 56 days at 10° F. and 24 days at 15° F. as representing approximately equal and real deteriorative changes than 13 days at either temperature. Additional data which show time-temperature equivalents over a range of 10-30° F. are presented in the paper on strawberries *(2)*.

Reproducibility. Since storage experiments, especially at low temperatures are often conducted over long periods of time, it would be of interest to examine some of the data with respect to reproducibility at various time intervals. As we have already seen in the case of raspberries, Figure 2 shows large fluctuations in percentages of correct answers up to the point where definite flavor changes begin to take place. It will be noted that both initially and after 12 months, significant results at the 5% level were obtained before any consistent increases in correct judgments were evident. After the initial fluctuations, however, there was excellent agreement among the results obtained at 0, 6, 12, and 18 months.

The largest total variation in correct answers for any given time was approximately 10% and this oc-

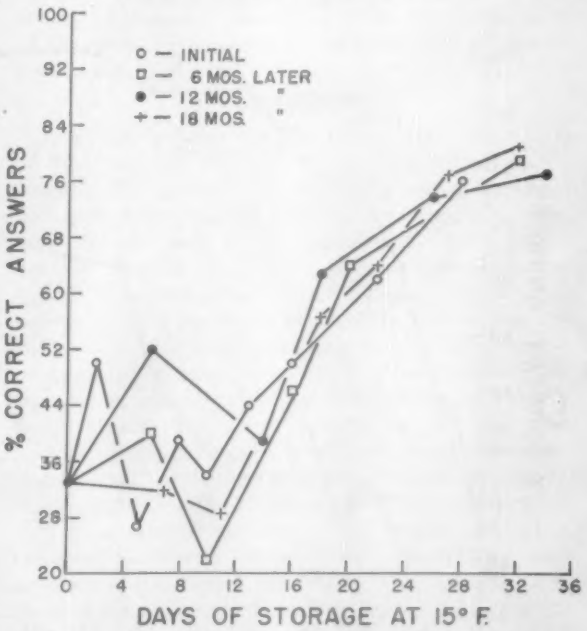

Figure 2. Effect of various storage periods at −20° F. on the reproducibility of flavor results obtained from frozen strawberries held at 15° F.

curred in the range of 54 to 64%. In the range of 70% correct answers and above, the total spread in correct answers varied from 4 to 6% indicating less variation as the deteriorative change became larger. Additional data pertaining to reproducibility are presented in Table 1. Inspection of the data in this table readily indicates that there are no significant differences in the percentage of correct responses obtained initially and after 3 months or one year at -20° F. However, it is again apparent from the standard deviations of the percentage of correct answers that much better reproducibility is obtained in the range of 76 to 86% than at 50 to 67% correct answers. The standard deviation is approximately 3 to 5 times larger for the lower level of correct responses, indicating much more variability in this range.

The extent of variation around the mean for the tests conducted after 3 months of storage at -20° F. is shown graphically in Figure 3. These plots very clearly show the superior reproducibility which was obtained in the higher range of correct responses for both strawberries and raspberries.

TABLE 1

Reproducibility of Flavor Results After 0, 3 and 12 Months of Storage at −20° F.

Product	Temperature history	Mean and standard deviation of percent correct answers in eight taste sessions of 20 triangles each		
		Initially	3 months later	12 months later
Strawberries	15° F. for 17 days	60.6 ± 14.2	63.8 ± 12.3	67.5 ± 11.5
Strawberries	20° F. for 9 days	76.7 ± 4.7	78.8 ± 4.1	77.5 ± 4.3
Strawberries	20° F. for 13 days	84.9 ± 5.1	85.5 ± 4.6	86.3 ± 4.8
Raspberries	15° F. for 17 days	57.3 ± 6.8	50.0 ± 15.6	52.5 ± 12.3
Raspberries	20° F. for 21 days	85.0 ± 4.8	82.0 ± 3.5	85.0 ± 5.1

The reproducibility of the mean percentage of correct answers, together with the relatively small standard deviations for the 76 to 86% range, probably accounts for the observation that differences which give rise to this level of significance are more nearly equal than those at the lower level. The equality of differences obtained during storage at various temperatures is of utmost importance. As shown in a previous

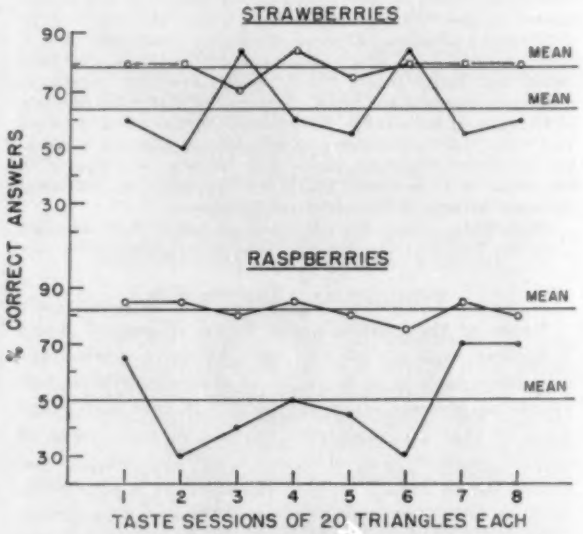

Figure 3. Variation in flavor results from strawberries and raspberries at two levels of difference from the controls. Means for each difference level were calculated from results of all 8 taste sessions or 160 triangles.

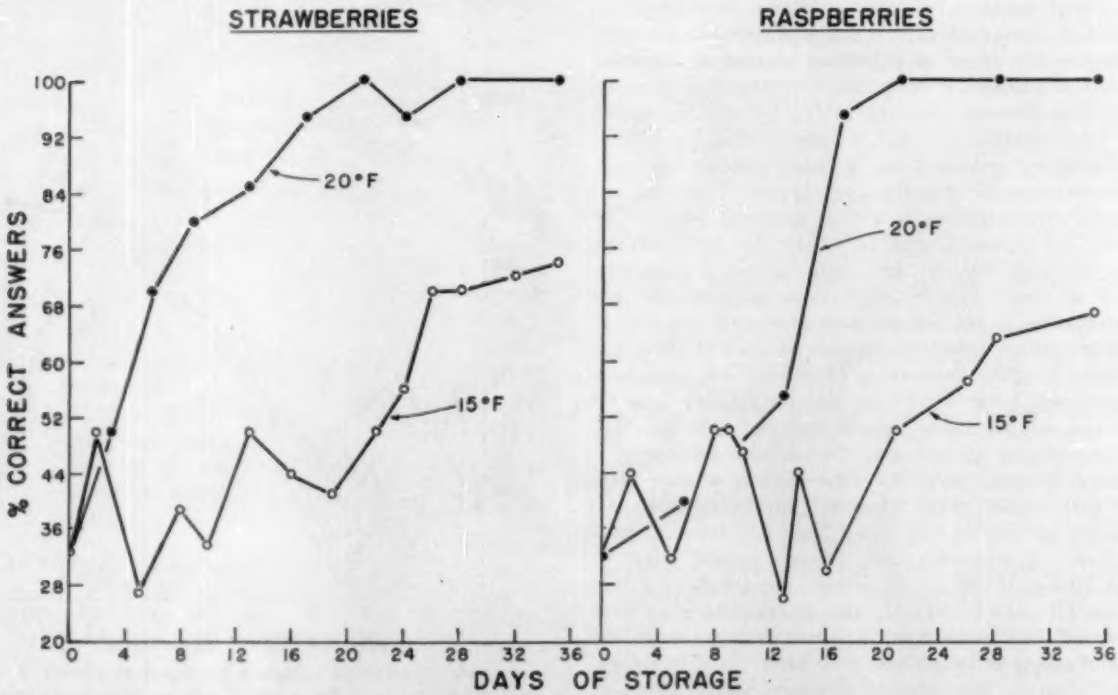

Figure 4. Effect of temperature on rate of flavor change in strawberries and raspberries.

example, real temperature effects may be entirely missed or at best inaccurately assessed if the organoleptic differences obtained at different temperatures are not approximately equal. The excellent reproducibility obtained over a period of 18 months on samples of the same degree of deterioration (70-85% correct answers) indicates that in the hands of sensitive, well-trained tasters this procedure gives a fairly accurate estimation of the time required to develop approximately the same degree of deterioration at various temperatures.

Effect of temperature. Figure 4 shows the results obtained at 15° and 20° F. for strawberries and raspberries. From these curves it is clear that the rate of deterioration is much more rapid at 20° as compared to 15° F. At 20° F. there is a relatively rapid and consistent increase in correct answers with time, indicating a rapidly increasing degree of deterioration. The increased rate of deterioration at 20° F. undoubtedly explains the fact that there are no appreciable fluctuations in percentage correct answers, but a steady and rapid increase with time. This is in line with the hypothesis that as the difference between samples becomes larger, segregation of the duplicates is facilitated and consequently the percentage correct answers increases. Interpretation of the results at 20° F. is a simple matter, since the curves are consistent and well defined. At 15° F., however, we must first determine the point where random fluctuations cease and a consistent increase in percentage of correct answers commences. Only the latter portion of the curve is useful in determining rates of deterioration or the time required for equivalent differences.

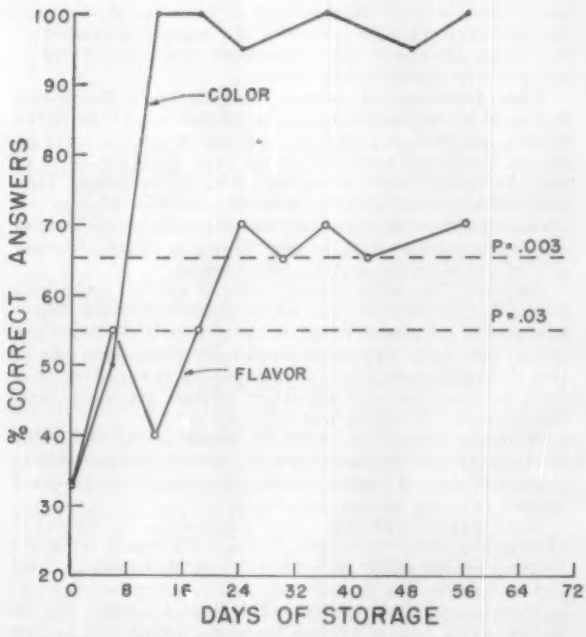

Figure 5. Relative rate of flavor and color change in frozen peaches stored at 20° F.

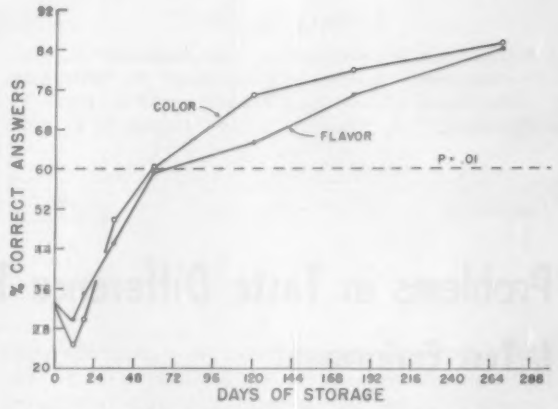

Figure 6. Relative rate of flavor and color change in frozen peaches stored at 10° F.

Usefulness of this approach in determining the relative rates of color and flavor change in frozen peaches stored at different temperatures is shown in Figures 5 and 6. At 20° F. color changes occur at a rate approximately three times faster than flavor and the extent of the changes as indicated by the percentage correct responses is much greater for color than for flavor. On the other hand Figure 6 shows that color and flavor changes at 10° F. both occur at approximately the same rate and to the same degree of difference from the control samples. It is also apparent from the curves in Figures 5 and 6 that the rate of color and flavor change is much more rapid at 20° as compared to 10° F. Thus the procedure of plotting correct responses versus time not only gives an accurate estimation of the rate of change at various temperatures but also allows for comparison of the effects of different temperatures at any given level of change as represented by the percentage of correct responses.

SUMMARY

A simple concept for the organoleptic evaluation of food products held at various temperatures is described. The procedure involves the use of an objective-type difference test such as the triangle to compare samples held at an experimental temperature against controls maintained at a temperature low enough to prevent deteriorative changes. The percentages of correct responses obtained in such a test are then plotted against time and the resulting curve provides information with regard to the rate and relative magnitude of the changes occurring at various temperatures. The curve obtained in this way also allows for comparison of results at any given probability level. Data are presented to show the effect of temperature and the reproducibility of the method over long periods of time. With commercial retail samples of frozen strawberries, raspberries, and peaches, it was found that 70 to 85% correct judgments gave more accurate and reproducible results than the percentage corresponding to a 5% level of significance.

LITERATURE CITED

1. Guadagni, D. G., Nimmo, C. C., and Jansen, E. F., Time-temperature tolerance of frozen foods. II. Retail packs of frozen peaches. *Food Technol.*, 11, 33-42 (1957).
2. Guadagni, D. G., Nimmo, C. C., and Jansen, E. F. Time-temperature tolerance of frozen foods. VI. Retail packs of frozen strawberries. *Food Technol.*, 11, 389-397 (1957).
3. U. S. National Bureau of Standards. Tables of the Binomial Probability Distribution. Applied Mathematics. Series No. 6. 1950.

Problems in Taste Difference Testing

I. Test Environment

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It is agreed that a proper environment is necessary for successful taste testing. But what the requirements of such an environment are and what may be the practical limits of control have been open to some question. That different types of taste testing require different degrees of control is evident. Whatever the degree required, however, the only reason for control is to facilitate the tasting task by eliminating anything that could detract from complete concentration.

All tasting judgments other than the most naive acceptance or rejection involve a great deal of mental effort. Probably the easiest mental task in a taste testing situation is comparing different intensities of a basic taste. Here the subject need only make an estimate of taste intensity. From this the difficulty of the psychological task increases rapidly since any one or a combination of factors may be introduced.

First of all, as the taste of the samples becomes more complex—as in beer, for instance, which contains all of the basic flavors—the mental process becomes increasingly involved. The subject must decide what flavors are present, the intensity of each, the temporal order in which they are perceived, and the interaction of the flavors. In addition, he must consider the tactual properties of the sample.

Moreover, as the subject becomes more sophisticated in judging, his mental process grows more complex because his perception and ability to analyze have become more acute. Thirdly, as the judgmental task becomes increasingly complicated, greater sensitivity is required and the taste analysis must therefore be more penetrating.

In a taste difference test the degree of mental effort required is directly related to the amount of difference between samples. Probably the most difficult area therefore is control testing in which normally uniform production samples are compared with a standard.

Laboratories universally have recognized in these circumstances the compelling need for a distraction-free testing environment; hence the ubiquitous tasting booth, usually air conditioned, and the request for silence during sessions. How important these controlled conditions may be is still not known. It is the purpose of this paper to concentrate on the effect of distraction on sensitivity in the taste difference test and to offer empirical evidence with regard to its importance.

EXPERIMENTAL

Data for this study were collected under normal operating conditions as they have prevailed in this laboratory for several years:

Physical conditions. All tests in this laboratory are conducted in a tasting room approximately 12 x 12 ft. which has its own air conditioning system. The room contains 5 booths in a semicircular arrangement. Each booth is separated from the next and also from the preparation area by a 5 foot high partition. The partitions between booths extend 2 to 3 feet behind the subject's seat so that there is no visual contact between subjects. Partitions and walls of the testing room are off-white in color. Responses are made by use of numbered tabs and the correctness or error of the response is reported to the subject after each test with colored cards. No talking is required or permitted during the test.

Taste difference test method. The duo-trio is the method used in which the subject receives in sequence one of the paired samples identified as a reference followed in random order by the odd sample and the second of the pair. He is instructed to select the sample which is different from the reference. Temperature, color, and quantity differences between samples are eliminated or controlled as is the time interval between samples and between tests. Each subject takes 5 tests on the same pair of test materials during a single session.

Subjects. The entire regular panel of subjects (who have participated in tests for from several months to several years) were used in the present study. Subjects came to the laboratory at any time when they could conveniently leave their jobs so that there were from 1 to 5 subjects testing at any given time. With the exception of 2 laboratory workers the entire panel was composed of foremen and union labor.

Materials tested. The materials tested during the period of this study were the routine samples normally tested including those from tanks of finished beer as well as completely processed samples from the bottling department.

Experimental conditions. Data collected as the proportion of responses correct were segregated into 3 groups based on the presence or absence of distraction during the conduct of the test as follows:

Condition A. Only one subject testing at a time. No one in the testing room other than the single subject and the test operator. No noise or disturbance during the testing period.

Condition B. Two or more subjects testing at a time. No

one in the testing room other than the subjects and the test operator. No noise or disturbance during the testing period.

Condition C. One or more subjects testing, with noise or distraction occurring. (This condition was never purposefully provided, but tests were classified under Condition C when any distraction or noise occurred.)

RESULTS AND DISCUSSION

Results of this experiment are presented in Table 1. The difference in the percentage of responses correct is significant beyond the 1% level between all conditions. The lowering of sensitivity between Condition A and Condition C was certainly expected and has been recognized by most laboratories as indicated by the testing conditions normally prevailing. On the other hand, the significant drop from Condition A to Condition B was not entirely expected and is not reflected in normal practice in that it is usual rather than unusual for several subjects to test at the same time. Nevertheless, the data strongly suggest that for optimum sensitivity single tests be used.

Any hypothesis based on this study as to the reason for the Condition A to B drop must be highly speculative. However, it seems evident that despite the fact that there is no overt distraction, simple knowledge of the presence of another subject during a test provides enough disruption to the subject's concentration to significantly lower his sensitivity. The drop in sensitivity from Condition B to C goes beyond this psychological distraction and must be attributed to physically distracting factors such as noise.

The entire study offers positive evidence of the necessity for concentration and emphasizes the importance of psychological and physical conditions on the sensitivity of the taste difference test.

TABLE 1

Sensitivity under varying test conditions

Condition	Total tests	Number correct	Percent correct	σp
A	3820	2716	71.10	0.735
B	1435	942	65.64	1.25
C	390	218	55.90	1.41

Difference compared	σ difference	Critical ratio	Significance
A–B	1.45	3.77	.0001
A–C	2.62	5.80	.0001
B–C	2.81	3.47	.0003
A–B, C	1.59	4.74	.0001

Problems in Taste Difference Testing

II. Subject Variability Due to Time of the Day and Day of the Week

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THE SERIOUS EFFECT of environmental conditions on the sensitivity of the taste difference test has been shown in the previous article *(1)*. It was pointed out that psychological distraction such as knowledge of another subject's presence during a test as well as physical distraction such as noise can have a deleterious effect on taste sensitivity. It is the purpose of this paper to investigate the psychological and physical effect of time on the sensitivity of the taste difference test subject.

For example, will subjects be more sensitive at a particular time of the day? Are they fresh and therefore sensitive in the morning? Or are they still psychologically asleep and comparatively insensitive? Does their anticipation before lunch time increase their taste acuity or does it interfere with their concentration? What level of sensitivity will they maintain in the period immediately after eating? Will the psychological lift of the change and rest provided by the lunch period offset the supposed desensitizing effect of eating?

How about the day of the week? Is Monday the best day because the subject has been resting from his job over the weekend? Or is the "blue Monday" effect more important? Do subjects do worse as the week wears on and they become tired (or bored)? Or do they do better through a warm-up or practice effect or through a heightening anticipation of the approaching weekend?

The experimental data for this paper were obtained from the records of routine daily testing. As such they can provide an answer to what happens to sensitivity hour by hour or day by day, but they can not tell us the *why's*. Certain *why* answers, however, have been popularly assumed.

For example, it has been almost universally agreed that one can not taste as well immediately after eating as at other times. It has also been generally assumed that physical fatigue will decrease the efficiency of the taste performance. It was assumed that the results of this study would refute these beliefs if proven false. But if, on the contrary, the fact of lowered sensitivity is shown to exist under these circumstances, it would still not "prove" the beliefs. Only two specific questions then will be answered by this study:

1. Is there a significant variation in sensitivity over the hours of the working day when subjects test at regular intervals throughout the day?
2. Is there a significant variation in sensitivity over the days of the week when subjects test at regular intervals throughout the week?

EXPERIMENTAL

Conditions under which the data were obtained for the day of the week comparison have been described in detail previously *(1)*. Conditions for the hour study differed in several minor respects, but primarily in that a fixed group of 7 subjects took 2 duo-trio tests on various alcoholic products approximately every 15 minutes through the 8-hour work day. These subjects worked full time as tasters and continuance in the work was dependent on their level of performance.

Data were collected as the proportion of responses correct. Differences between hours and between days were analyzed by normal statistical procedures involving standard error of the difference and Z scores *(2)*.

RESULTS AND DISCUSSION

Results of the day by day sensitivity comparison are presented in Table 1 and shown graphically in Figure 1. The differences between days are small. Monday starts the week slightly below average. Tuesday is significantly better than Monday and also significantly higher than the average. Wednesday and Thursday are down again, approximately to the level of Monday, and Friday shows an upturn about to the weekly average. The superiority of the results obtained on Tuesdays is significant beyond the .01 confidence level over all other days. There are no significant differences, however, between the other days.

Although it is in no sense established by this study, data seem to support a simple psycho-physical theory that the subject does better during the earlier part of the week when he is fresher, but poorer later in the week when he is becoming fatigued or bored. The contra-indications are that the psychological impact of Monday depresses that level and the lift of reaching the end of the work week tends to raise Friday's level.

TABLE 1

Day of the week	Total responses	Correct responses	Percent correct
Monday	4005	2560	63.920
Tuesday	4070	2667	65.528
Wednesday	4430	2829	63.860
Thursday	4370	2789	63.822
Friday	4380	2881	64.406

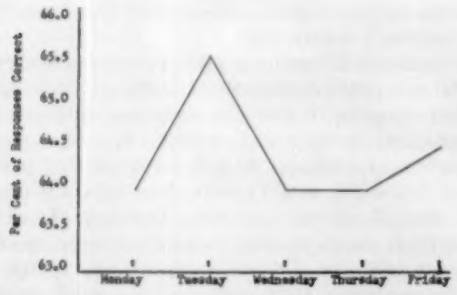

FIGURE 1

Table 2 and Figure 2 show the results of the hour of day comparison. Here the results are not in accord with one widely accepted belief. The fourth hour of the day includes the ½ hour before lunch and the ½ hour immediately after lunch, and rather than being low, it is the second best hour of the day. This is certainly strong evidence that although eating per se may dull the sensory receptiveness, other physical or psychological factors counteract this to the extent of making the period immediately after lunch better than most of the other times of day.

TABLE 2

Hour	Time of day	Total responses	Correct responses	Percent correct
1	8:00– 9:00	3274	2041	62.340
2	9:00–10:00	2584	1612	62.345
3	10:00–11:00	3638	2244	62.205
4	11:00–12:30	3448	2265	65.081
5	12:30– 1:30	3516	2156	64.420
6	1:30– 2:30	3306	2263	65.215
7	2:30– 3:30	2688	1702	63.318
8	3:30– 4:30	3278	2022	61.684

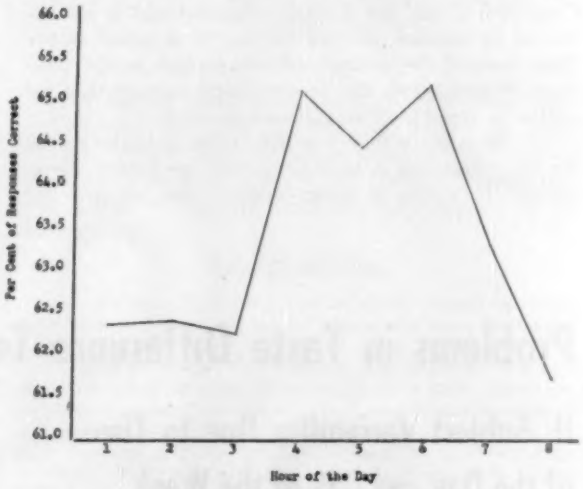

FIGURE 2

The data shown in Figure 2 follow a warming-up trend to a high middle of the day plateau, then a falling off to the end of the work period. In this case the fourth, fifth and sixth hours are significantly superior to all other hours. The seventh hour, though significantly lower than the sixth, is significantly higher than the last. (All are significant beyond the .01 probability level.) No other between-hour differences are significant.

Again, although not experimentally established, it seems likely that the early morning hours represent a period when the subject is not quite able to give full concentration to the task, by the middle of the day he is in "high gear" but not yet fatigued, and by the last hours of the day he has given his best effort and is on the down grade.

It should be noted that both parts of this study represent a continuous and relative effect since each

piece of data is dependent on preceding data. That is, in the day part of the study the same subjects tested every day, and under these circumstances Tuesday was the best day. This does not mean that, if subjects are to test just one day of the week, Tuesday will necessarily be the best day. It could mean, for example, that the second day of testing, regardless of the day of the week, would be the best.

Similarly, in the hour part of the study, the same subjects tested during all hours of the day, and in this case the middle of the day was significantly superior. But this does not insure that the middle of the day will be the best time for subjects to take their tests when they test just once a day. There may well be nothing intrinsically superior about the middle of the day, except that in these particular circumstances it represents the optimum combination of "warming-up" and lack of fatigue.

The most important information that can be drawn from this study is the further evidence provided that the human subject is not capable of machine-like performance but is susceptible to influence by many physical and psychological conditions. The laboratory supervisor will be better able to properly interpret his results when he recognizes this fact and evaluates the various influences that may be affecting his subjects on any particular test.

Finally, in refuting the after-meal dullness theory, the study offers another example of the precarious position one assumes when following "logical theory" rather than experimental evidence.

LITERATURE CITED

1. Mitchell, John W. Problems in taste difference testing. I. Test environment. *Food Technol.* (This issue).
2. Duncan, Acheson J. *Quality Control and Industrial Statistics.* Irwin, Homewood, Illinois, 1953.

Objective Evaluation of Color and Consistency in Peach Puree[a, b, c]

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(Manuscript received May 15, 1957)

In a study of the factors affecting the color and consistency of purees made from eastern grown freestone peaches, it was desirable to establish objective criteria which could be related to organoleptic evaluations. Development of such quality indices would greatly alleviate the difficulties encountered in maintaining a trained panel of judges and eliminate certain variations due to fatigue in routine subjective testing of a large number of samples.

Measurement of peach color has heretofore been confined mainly to the raw product or processed halves and slices where visual comparison with color charts *(1, 7, 8)* or other visual aids *(2, 9, 10)* were employed. Several objective methods have been reported. Kramer and Haut *(6)* described a spectrophotometric and fluorimetric method for evaluating raw and canned product maturity. Grice *et al. (4)* used the Hunter Color-Difference Meter in describing the browning characteristics of frozen peach slices.

In work dealing with peach puree, Eolkin *(3)* reported a method of comparing color by the use of black and white photography. Hohl *et al. (5)* measured the color of canned and frozen puree with the Maerz and Paul *Dictionary of Color.* Consistency was evaluated with a Bostwick Consistometer.

EXPERIMENTAL

Elberta and Halehaven peaches were pureed in the pilot plant at Geneva during the 1955 and 1956 seasons with the fruit maturity and processing conditions controlled so that a wide range of color and consistency was obtained. Following each season, representative samples were selected for variations in color and consistency and scored on the basis of these factors by a trained panel of 20 judges. A commercial sample prepared from Modesto Midsummer (Clingstone) peaches served as a control in each panel session.

Objective tests. Color and consistency measurements were made at the time of processing and again on a portion of the sample viewed by the panel as follows:

Color. Reflectance measurements, by means of the Hunter Color-Difference Meter, were made on purees in a sample cylinder of optical quality Plexiglas, 2⅝ in. in diameter, filled to a depth of 2 in. A standard reference tile (National Bureau of Standards K. & B. No. 6, Hunter $L = 74.7$, $a_L = 0.1$ and $b_L = 32.2$) was used in conjunction with the wide aperture and small area illumination settings on the instrument.

Consistency. The Brookfield Synchro Lectric Viscometer and Bostwick Consistometer were used for consistency measurements. For Brookfield measurements a 200-ml. tall form beaker was filled with puree to a depth of 3½ in. and the scale value attained after 10 revolutions of the No. 3 spindle operating at 12 r.p.m. was recorded. Bostwick values were recorded as the distance (in centimeters) of flow which occurred within 10 seconds. All measurements were conducted at 86°F. and run in triplicate.

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[a] Presented at the Seventeenth Annual Meeting of the Institute of Food Technologists, May 15, 1957, Pittsburgh, Pa.

[b] This report deals with research accomplished in part under a contract with the U. S. Department of Agriculture and authorized by the Research and Marketing Act of 1946. The contract is being supervised by the Eastern Utilization Research and Development Division, ARS.

[c] Journal Paper No. 1089 New York State Agricultural Experiment Station, Cornell University, Geneva, New York.

Taste panel. In an effort to reduce the interaction of color on consistency scores (or vice versa) each attribute was scored individually in separate sessions. Further, when scoring for color the judges were instructed not to stir or taste samples. Color was scored under north daylight with the light intensity maintained at approximately 8 foot candles by means of adjusting the distance between the sample and light source. Light intensity measurements were made with a GE light meter.

Consistency scoring was conducted in a room illuminated with a sodium vapor lamp (589 mμ) so as to disguise sample colors.

Since 60 samples (50 test samples and 10 controls) were scored for color and consistency it was found convenient to use a multiple comparison test wherein each judge scored 5 test samples and one control for color and consistency twice daily. A practice session was used to familiarize judges with score sheets and the values obtained served as a means of selecting judges.

Sampling. Each sample consisted of 6, 8-ounce jars of puree which were randomly selected from lots of 24. The contents were mixed and a 25 per cent aliquot removed for the objective color or consistency measurement. The remainder was presented to the panel.

Color. Samples were viewed in 8-ounce glass babyfood jars placed on a stand at eye level and illuminated from a source located behind the judges. The order of presentation was designed so that the 5 test samples represented a wide range of color. This helped reduce the "downgrading" effect sometimes encountered when all samples are well colored or the "upgrading" when all samples are poorly colored. The 50 test samples were arranged in order of increasing Hunter b_L values since preliminary comparisons of visual scores and the b_L value gave a high correlation ($r = 0.78$). This array was then divided into 5 equal groups of 10 samples (Table 1).

One sample was selected from each group for each panel session. For the first session, the sample having the lowest b_L in each group was selected; in subsequent sessions, the sample having the lowest remaining b_L value, etc. Order of presentation, by group number, was randomized by reference to a table of random numbers.

Consistency. Samples to be scored for consistency were arranged on the basis of increasing Brookfield values. Both Brookfield and Bostwick values showed high correlations with visual scores in preliminary tests. Brookfield values were chosen due to the wider range (Brookfield = 68 to 9630, Bostwick = 4.6 to 17.7). This array was then divided into 5 groups of 10 samples as shown in Table 2. The order of presentation was randomized by groups number, the sample having the lowest Brookfield value in each group selected for the first session and the lowest remaining values in each group for subsequent sessions. Each judge received about 30 ml. of puree in coded Petri dishes and was permitted to ladle and taste the samples.

Score sheet. The score sheet used for evaluating color and consistency provided spaces for 6 sample codes. For color, the judges were instructed to list the samples in order of increasing desirability of color. For consistency, the samples were listed in order of increasing thickness. Beside the entry space for each sample code was a horizontal scale 10 centimeters long with unnumbered gradations. It was explained that this scale was of continuous nature with the left end representing the poorest color or thinnest consistency and the right end of the scale representing the opposite extreme, depending on the attribute being scored. The relative value of each sample was indicated by the judge placing a check mark over one of the scale gradations.

Tabulation. The distance between the left end of the scale and the judge's check mark was converted to centimeters and represented the numerical score from 0 to 10. The average of 20 scores for color and consistency was then compared with the corresponding objective measurement for each sample.

TABLE 1

Grouping of samples for presentation to color panel

Group number	Hunter b_L range[1]		Number of samples
	Minimum	Maximum	
1	17.5	20.0	10
2	20.5	22.8	10
3	24.2	27.0	10
4	27.2	28.6	10
5	28.7	31.1	10
6[2]	25.5	28.4	10

[1] Based on measurements made at the time of processing.
[2] Controls.

TABLE 2

Grouping of samples for presentation to consistency panel

Group number	Brookfield range[1] (apparent cp.)		Number of samples
	Minimum	Maximum	
1	68	2142	10
2	2192	2922	10
3	3032	4162	10
4	4354	5532	10
5	5568	9630	10
6[2]	6164	6847	10

[1] Based on measurements at the time of processing.
[2] Controls.

RESULTS AND DISCUSSION

Color. Figure 1 shows the relationship between actual scores assigned by the panel and scores calculated from the equation:

$$\text{Calculated Score} = -7.36 - 0.22\,(\text{Hunter L}) + 0.45\,(\text{Hunter } a_L) + 0.64\,(\text{Hunter } b_L)$$

In comparing visual color scores with Hunter Color-Difference Meter values, the highest correlation was obtained when L, a_L and b_L values were used in multiple relationship. The coefficient of the multiple correlation for panel score vs. L, a_L and b_L was 0.811.

It was noted that when extreme differences in color saturation were not encountered the Hunter b_L value correlated highly with panel score. This was especially true in the range $b_L = 19$ to 25. With wider color saturations the L (lightness) and a_L (red to green) stimulii apparently play a greater part in assessing color score.

An investigation of the relationship between various combinations of Hunter values with panel color scores gave coefficients of correlation as shown in Table 3: $L = 0.496$, $a_L = 0.702$, $b_L = 0.729$, $a_L/b_L = 0.597$ and $(a_L^2 + b_L^2)^{1/2} = 0.744$. Multiple correlations with two independent variables gave the following coefficients: $L,a_L = 0.718$, $a_L,b_L = 0.785$, and $L,b_L = 0.768$.

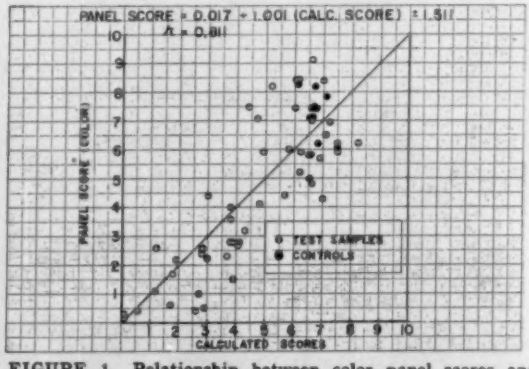

FIGURE 1. Relationship between color panel scores and scores calculated from tristimulus values.

TABLE 3

Correlations of panel scores with objective measurements of color and consistency

Factors[1]	Regression equation Yc =	Correlation coefficient[2]	Standard error of estimate	95% confidence limit
Color score on Hunter L, a_L and b_L	$-7.36 - 0.22\ L + 0.45\ a_L + 0.64\ b_L$	0.812**	1.511	2.89
Color score on Hunter $a_L + 10$ and b_L	$-10.84 + .495\ (a_L + 10) + 0.3577\ (b_L)$	0.785**	1.606	3.04
Color score on Hunter L and b_L	$5.18 - .24\ (L) + .86\ (b_L)$	0.768**	1.658	3.13
Color score on Hunter $(a_L^2 + b_L^2)^{1/2}$	$-9.03 + 0.55\ X$	0.744**	1.731	3.30
Color score on Hunter b_L	$-9.00 + 0.56\ X$	0.729**	1.774	3.31
Color score on Hunter L and $a_L + 10$	$-10.09 + .09\ (L) + .77\ (a_L + 10)$	0.718**	1.802	3.40
Color score on Hunter $a_L + 10$	$-7.37 + 0.89\ X$	0.702**	1.844	3.42
Color score on Hunter L	$-7.37 + 0.26\ X$	0.496**	2.250	4.23
Consistency score on Brookfield	$-0.15 + 0.001\ X$	0.907**	1.169	2.13
Consistency score on Bostwick	$12.31 - 0.778\ X$	−0.956**	0.799	1.47

[1] For the regression calculation the second named factor is the independent variable (X) in the equation. The first named factor is the dependent variable (Y). The coefficient of (X) is the slope of the curve between the two variables.
[2] Significant at the .01 level.

Consistency. The relationship between panel scores for consistency and Brookfield values is illustrated in Figure 2, and with Bostwick values in Figure 3. From these data it is apparent that highly significant correlations were obtained when either instrument was compared with consistency scores as noted in Table 3. With Brookfield values the coefficient was 0.907 and with Bostwick values, —0.956. (Note: low Bostwick values indicate higher consistency). When the two instruments were compared a coefficient of —0.874 was obtained.

It was noted that the commercial control samples, as measured by the Brookfield, generally deviated from linearity. This may have been caused by varietal differences or processing conditions which altered the serum viscosity and/or particle size.

The higher correlation with Bostwick values, in addition to a smaller standard error of estimate, would indicate that this instrument was highly satisfactory for evaluating the consistency of the puree samples studied.

SUMMARY

Objective methods for evaluating the color and consistency of peach puree were investigated. The Hunter Color-Difference Meter was used for measuring the color of peach puree. In comparing subjective color scores with Hunter values, the highest correlation was obtained when L, a_L and b_L values were used in multiple relationship (R = 0.811). With some sacrifice of accuracy the b_L value alone might serve as a color index where wide variations in saturation are not encountered.

Correlations of subjective scores for consistency with Brookfield SynchroLectric Viscometer and Bostwick Consistometer gave coefficients of 0.907 and —0.956, respectively. In successive measurements on control samples, smaller variance and ease of operation indicated that the Bostwick was highly satisfactory for routine testing.

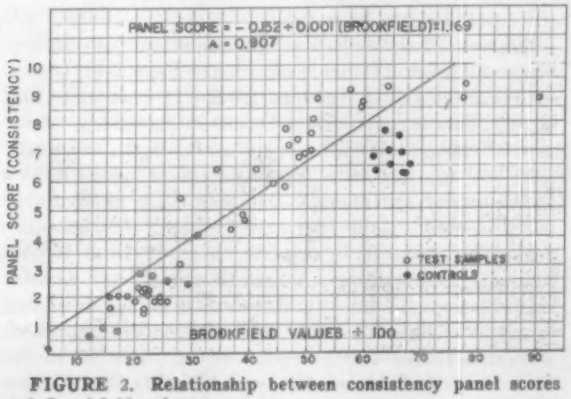

FIGURE 2. Relationship between consistency panel scores and Brookfield values.

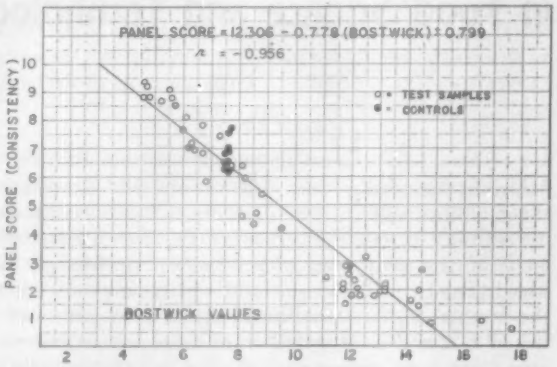

FIGURE 3. Relationship between consistency panel scores and Bostwick values.

LITERATURE CITED

1. Bedford, C. L., and Robertson, W. F. Harvest maturity and ripening of peaches in relation to quality of the canned and frozen product. Michigan State Agricultural Experiment Station. *Tech. Bull. 245* (1955).
2. Bureau of Fruit and Vegetable Standardization, California State Department of Agriculture. A preliminary study of known indices for determination of shipping maturity for freestone California peaches. (1953).
3. Eolkin, D. Relative color evaluation of food purees using black and white photography. *Food Technol.*, 6, 197-236 (1952).
4. Grice, M. R., Brown, H. D., and Burrell, R. C. Browning of frozen peaches. *Food Eng.*, 24, (1) 131-139 (1952).
5. Hohl, L. A., Buck, P., and Rosoff, H. Further studies on frozen fruit and vegetable purees. *Food Technol.* 3, 100-110 (1949).
6. Kramer, A., and Haut, I. C. Ripeness and color studies with raw and canned peaches. *A. S. H. S.*, 51, 219-224 (1948).
7. Neubert, A. M., Schultz, J. H., Bedford, C. L., and Carter, G. H. Processing Washington-grown freestone peaches. State College of Washington Agricultural Experiment Station, Pullman, Washington *Sta. Cir. 63* (1948).

8. Upshall, W. H., and Van Haarlem, J. R. Quality and control of fruit, fresh and processed, as affected by stage of maturity at picking time. Hort. Exp. Sta. Vineland Station, Ontario. (1945).
9. Whipple, S. R. Color comparison tests to measure maturity of canning cling peaches. State of California Dept. of Agriculture. Sacramento, Calif. (1951).
10. Whipple, S. R. Color inspection — fresh fruits and vegetables, The Bulletin, Department of Agriculture, State of California. Vol. 64, No. 2, pp. 47-55 (1955).

Notes and Letters

Literature Search and Reference Citation in Food Science and Technology*

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Use of prior scientific and technological knowledge and observations and transmittance of this information to others is fundamental in the training of research personnel. Continued advancement of our knowledge of science and technology is based largely on the extent and ability to profit from the experience of others. Knowledge of previously published data and interpretations of it are not only necessary to prevent unnecessary duplication of laboratory research already available but also in better planning and organization of research programs. This is particularly true in an applied science field like food and food products technology. Second only to the ability to recognize and delineate the more important problem or problems is the ability to select and utilize the particular scientific discipline and methodology which will best lead to its solution. Library research is not only of direct value in uncovering data already reported but is even of greater value in inspiring or suggesting research problems or techniques that may lead to significant new discoveries *(8)*. Too often in food science research, a search of the literature is made after the laboratory observations have been completed and used largely, if not solely, in the preparation of the paper for publication.

Vigorous prosecution of programs of research on the ever increasing front of science, intensification of research in delimited narrow fields of specialization, and the phenomenal recent increase in the utilization of science in technology have introduced many problems both to the editor and reader. The great expansion, aptly characterized as an explosive expansion *(8)*, of sciences and their application, has brought such limitations and restrictions on the space available per article that an adequate review of earlier publications often can not be made. This condition is only partly solved by the introduction of annual reviews and advances publications in a number of fields, by the introduction of highly specialized journals in particular fields of science, and by publication of articles directed to special audiences. Although the field of food science has benefited also from these developments, the particular need of the food technologists for wide, general knowledge of the basic biological and physical sciences and their application to food industries can not be adequately met by publications of articles directed to and understandable only by a highly specialized audience.

The present rapid accumulation of scientific and applied literature in a volume that "increases at a much faster rate than it is digested and efficiently utilized," to quote Connolly *(3)*, has been attested to often in recent publications *(2, 4, 6, 8, 9, 11)*. Increase in the number of particular scientific fields from two, natural philosophy and natural history, to over two hundred; the increase in the number of articles abstracted by abstract journals such as *Chemical Abstracts, Biological Abstracts*, etc.; increase in the number of journals abstracted and other measures of this literature expansion have been cited. These criteria have discouraged persons from attempting mastery of all but one or at most few fields. Too many rely upon abstracts or digests of abstracts for information. These at best can but indicate trends and too often are based on the author's own summary rather than on a critical and expert appraisal of the experimental results and conclusions. They often miss particularly cogent information useful in another field or at a later time.

Sources of information and methods of library research in several fields of science have been extensively discussed in various guides to reference material. This is particularly true of chemistry where several classic and still largely useful books are available *(5, 10, 12, 13)*. Professor E. Emmet Reed's *Introduction to Organic Research* is a particularly useful guide to the spirit of research for students beginning research in organic chemistry and is particularly stimulating. A recent, brief but concise introduction to the literature of organic chemistry is given in Cason's text *(3)*. Although comprehensive and authoritative sources of information in the food research field are not available, there are a number of useful sources.

Sources of information in food research. These

*Presented in part at the Meeting of the Editorial Boards, Seventeenth Annual Meeting of the Institute of Food Technologists, Pittsburgh, Pennsylvania, May 11, 1957.

sources include several compendia of information on the structure and composition of foods, general reference texts on chemistry and technology of food and food products, monographs on particular foods and crops, such series as Mrak and Stewart's *Advances in Food Research*, and various abstracts journals and sources—*Chemical Abstracts, Bacteriological Abstracts, Botanical Abstracts, Biological Abstracts, Nutritional Reviews*, etc. *Biological Abstracts* was founded originally by the Union of American Biological Sciences in 1926 at which time publication of *Abstracts of Bacteriology* by the Society of American Bacteriologists started in 1917 and of *Botanical Abstracts* ceased. In 1939 the form of *Biological Abstracts* was changed and it was issued in various sections. Winchell *(13)* discusses fairly completely these and other reference sources. *Nutrition Reviews* and the British Medical Research Council's *Nutrition Abstracts* and *Reviews* are particularly useful as sources of information available in this field. *Chemical Abstracts* publishes many abstracts of current articles of interest to food technologists, not only in the section on foods *(12)* but also in a number of other sections (Nos. 1, 7, 10, 11, 14, 15, 15A, 27, 28). *Chemisches Zentralblatt* is still useful for older sources of information since it was started in 1830; *Chemical Abstracts* began in 1907 and was materially expanded after World War I. *British Abstracts*, founded in three sections in 1926, and particularly the abstracts published by various British bureaus and departments, are most useful. The latter include *Dairy Science Abstracts* founded in 1939, *Field Crop Abstracts* in 1948, *Horticultural Abstracts* in 1931, and the *Index to the Literature of Food Investigation* begun in 1929 and continued as *Food Science Abstracts* since 1951. In addition, selected abstracts are published in a separate section of the *Journal of Food and Agricultural Science* and also in *Food Technology*. The Research Department Library of the American Can Company *Abstracts* published since 1934 are also available.

The literature resources for chemical process industries were discussed at several recent meetings of the American Chemical Society and a collection of papers comprising symposia and thirteen papers presented before the Division of Chemical Literature has been published *(1)*. One of the symposia was on the literature resources of the food industries.

Various publications of the Federal and State Agricultural Experiment Stations and articles in trade journals are only partly abstracted in *Chemical Abstracts*. During the period of 1905 to 1946 these were abstracted in the U. S. Department of Agriculture *Experiment Station Record* and in *The Agricultural Index* since 1919. The latter continues to publish a subject index to a selected list of agricultural periodicals and bulletins.

As pointed out previously, the abstracts journals and annual reviews such as *Annual Reviews of Biochemistry, Annual Reviews of Bacteriology, Annual Reviews of Plant Physiology* and the annual advances such as *Advances in Food Research* (1948 on), *Advances in Colloid Science* (1942 on), *Advances in Carbohydrate Chemistry* (1945 on), *Advances in Protein Chemistry* (1944 on), and *Advances in Enzymology* (1941 on) are guides to, but can not take the place of, the original articles in various periodicals. The large and increasing number of these serials has posed problems not only to the serious reader but also to the librarian. Lists of most frequently cited serials in pure and applied sciences have been published, but only recently have such lists been critically studied to ascertain what conclusions can be drawn from them for the guidance of libararians and scientists *(2)*. Brown *(2)* has called attention to the recent rapid increase in numbers and costs of scientific serials as they affect library policies on acquisition and maintenance. The number of scientific serials has more than doubled in the last two decades and if the present rate of increase continues there will be over 100,000 serials published in 1980!

CITATION

The citation of references in scientific journals varies as to frequency, style of citation, and kind of material cited. The rate of citation expressed in numbers of references cited per 100 pages of text for the more common scientific journals varies with field of science as shown in Table 1. According to the data obtained by Brown the literature of chemistry is documented to a greater extent than that of any science. The maximum rate of citation is given as 396.4 references per 100 pages for the *Journal of the American Chemical Society* and the minimum is 21.4 for *Acta Mathematica*. In zoology, entomology, and botany, citation to books is relatively greater than in physics, chemistry and physiology. In the physical sciences because of the rapid current advances the references cited are to newer rather than to older works.

In order to compare the current practice in the food science and technology field with the data presented and analyzed by Brown for the period of 1949–1952, similar data on reference citation in Food *Research, Food Technology* and related journals was obtained for the issues published in 1956. The data shown in Table 2 indicate that in references cited per article, average length of article and references cited per 100 pages of text, *Food Research* and *Food Technology* compare favorably with other journals. The number of references cited per article in *Food Research* varied from 0 to 40 while that for *Food Technology* varied from 0 to 37; but the average number of citations per article was considerably higher for *Food Research* than *Food Technology*. The latter,

TABLE 1*

Frequency of Reference Citation in Various Sciences

Science	References cited per 100 pages text
Chemistry	225
Physics	122
Physiology	119
Botany	89
Geology	75
Entomology	56
Zoology	47
Mathematics	33

* After Brown (2).

TABLE 2

Reference Citation in Food Science and Technology and Several Related Fields for 1956

Journal	Articles				Reference citations			
	Number	Pages text[1]	Length	Total	Per article	Per 100 pp. text	Per 100 pp. technical	Per 100 pp. review
Food Research	90	695	7.7	1128	12.5	162	.....	.....
Food Technology	167	638	2.5	1608	9.6	252	.....	.....
Applied Microbiology[2]	58	283	4.9	702	12.1	248	.....	.....
Cereal Chemistry	40	393	9.8	528	13.2	134	.....	.....
Industrial and Engineering Chemistry	393	2234	5.6	14,932	37.9	668	262	2094
Journal of Bacteriology[3]	128	724	5.7	1661	13.0	229	.....	.....
Journal of Agricultural and Food Chemistry	148	612	4.1	2118	14.3	346	413	202
Journal of the Science of Food and Agriculture[4]	108	728	6.7	1735	16.1	238	.....	.....
Plant Physiology[5]	82	409	5.0	1471	17.9	360	.....	.....
Proceedings of the American Society for Horticultural Sciences	86	586	6.8	765	8.9	130	127	250
Advances in Enzymology	10	498	49.8	1813	181	364	.....	.....
Advances in Food Research	7	372	53.2	1383	198	372	.....	.....
Advances in Protein Chemistry	6	384	64.0	1889	315	492	.....	.....
Annual Review of Biochemistry	23	706	30.7	5685	247	525	.....	.....

[1] Not including indices but including articles and reviews.
[2] For 5 issues, last issue not available.
[3] For 5 issues, last not available.
[4] For 11 issues, last not available.
[5] For 5 issues, last not available.

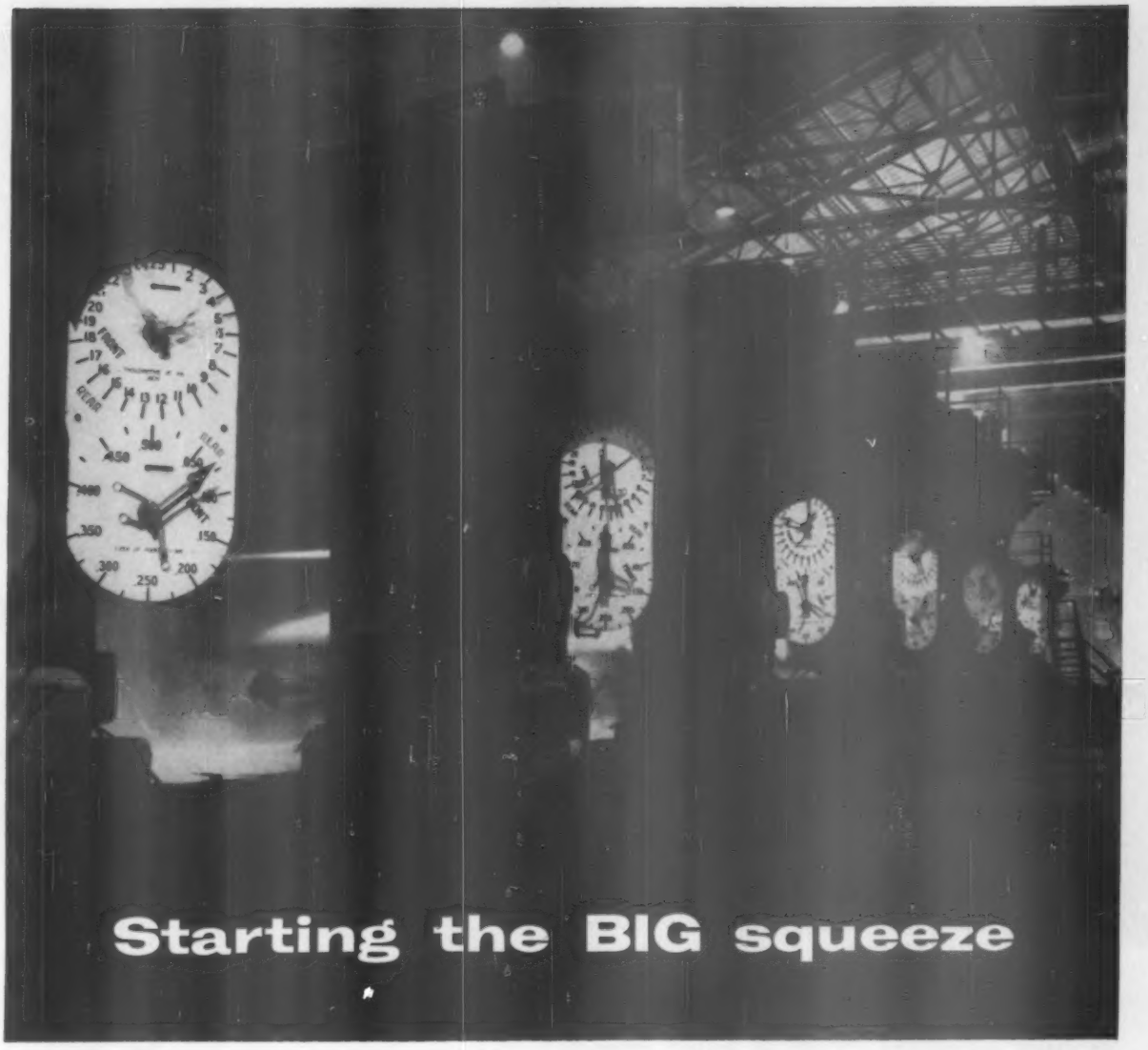
however, averaged considerably higher in number of citations per 100 pages of text.

It is not so much the rate of citations but the pertinence and the completeness of citation that is important. There is a marked variation in the completeness and pertinence of citations used in the introductory statements of the objective of the contributor(s), the experimental methods section and the discussion of the results obtained. This is only partly due to the style of presentation customarily used. The requirements of style of presentation and the current need for clarity in presentation are discussed in general in the widely quoted work of Trelease and Yale *(15)* and more recently by Thomas *(14)*. The need for improvement in clarity of scientific communications was discussed recently by Decker *(7)*. Several pamphlets on technical writing have been published. The editors of *Instrumentation*, have presented succintly a useful pamphlet "Some helpful hints for Honeywell technical writers." We are concerned here only in questioning whether the criteria of pertinance, adequacy, and sufficiency have been used in selecting the citation. Are the articles selected actually necessary to justify the statement made both from the standpoint of scientific honesty in crediting prior publication and clarification or justification of the conclusion drawn or implied? Too often there is a tendency to lump a number of references together to pad the "Literature Cited" section when a fewer number of references to reviews would suffice. This practice is as objectionable as disregard through carelessness or negligence of publications in the same and similar fields. Too often pertinent references have been omitted to similar work or other animal or plant species; the author of an article on "peas" may neglect to cite references to pertinent similar work on "spinach," for example. The references used must be both sufficient and necessary.

Toward more scholarly preparation of papers. There are many other aspects of literature review and reference citations that could be discussed but limitations of space and time prevent a more detailed treatment. The object of this article is to call attention to several points of literature review and citation so that articles for *Food Research* and *Food Technology* may be prepared in a more scholarly way and so that negligence of previous contributions with consequent embarrassment if not financial loss is avoided.

LITERATURE CITED

1. Amer. Chem. Soc., Division of Chemical Literature. Literature Resources for Chemical Process Industries. *Advances in Chemistry* Series No. 10, 1–582 (1957). See particularly general sections, pp. 438-547; and section on food industries, pp. 229–315.
2. Brown, C. H. *Scientific Serials. Characteristics and Lists of Most Cited Publications in Mathematics, Physics, Chemistry, Geology, Physiology, Botany, Zoology and Entomology.* A.C.R.L. Monograph No. 16, 189 pp. Assoc. of College and Reference Libraries, Chicago, 1956.
3. Cason, J. *Essential Principles of Organic Chemistry.* 530 pp. Prentice Hall Inc., New Jersey, 1956. See Chapter 37, pp. 487–505, for literature of organic chemistry.
4. Connolly, A. Library vs. laboratory research. *Ind. Eng. Chem., News Edition*, **18**, 904–905 (1940).
5. Crane, E. J., and Patterson, A. M. *Guide to the Literature of Chemistry.* 438 pp. John Wiley & Sons, Inc., New York, 1927. (Revised 1957)
6. Croft, K. Periodical publications and agricultural analyses. A bibliographical study. *J. Chem. Ed.*, **18**, 315–316 (1941).
7. Decker, F. W. Scientific communications should be improved. *Science*, **125**, 101–105 (1957).
8. Joslyn, M. A. Current developments in science likely to affect the food industries. *Fruit Products J.*, **20** (No. 9), 277–283, 288, 294 (1941).
9. Kimball, V. F. Chemical literature unlimited. *The Chemist*, **26** (No. 10), 385 (1949).
10. Mellon, M. G. *Chemical Publications, Their Nature and Use.* 2nd ed. 284 pp. McGraw-Hill Book Co., New York, 1940.
11. Myatt, D. O. The technical editors approach to an expanding literature. *The Chemist*, **30** (No. 3), 127–137 (1953).
12. Reid, E. E. *Introduction or Organic Research.* 343 pp. D. Van Nostrand Co., New York, 1924. See particularly p. 60–157.
13. Soule, B. A. *Library Guide for the Chemist.* 302 pp. McGraw-Hill Book Co., New York, 1938.
14. Thomas, E. When a chemist writes. *The Chemist*, **28** (No. 9), 387–391 (1951).
15. Trelease, S. F., and Yule, E. S. *Preparation of Scientific and Technical Papers.* 113 pp. Williams and Wilkins Co., Baltimore, 1925.
16. Winchell, C. M. *Guide to Reference Books.* 7th ed. 645 pp. American Library Association, Chicago, 1951.



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caffeine to carbohydrates we may control the degree of extraction which is one of the keys to flavor, all other things being equal. However, all other things are not equal. A heavy rainfall, a cold spell, a difference in drying the green beans and many other factors may, and do, affect the ultimate flavor. In addition, very few manufacturing processes are alike, and a blend that suits the purpose of one company will not necessarily suit that of another.

The specification lays down definite limits for such requirements as moisture, caffeine content, carbohydrates, and solubility. These can be determined readily by objective tests in the chemical laboratory. Types and grades of coffee beans are not specified because of reasons specified previously. In the spring of 1950, prior to completion of the specification, the first large scale consumer taste test was conducted at Great Lakes Naval Training Station. Samples of commercially available instant coffees were submitted by nine prime producers. Each sample of coffee was served to at least 380 enlisted men for evaluation. During the course of this experiment, sufficient information was obtained to draw up a taste test procedure which was then incorporated into the specification. The procedure is spelled out in rather complete detail in the specification. I refer you to the "spec" at this point rather than go into a long involved discussion.

The large scale consumer test for acceptance is conducted annually in order to keep up with the constant improvements taking place in the industry and to keep the acceptance standard at a high level. Since the coffee is procured for the Armed Forces' consumption, the tests have been conducted at military posts using enlisted men as subjects. The instant coffee is reconstituted and served in the same way as fresh coffee, under carefully controlled conditions. On the basis of 200 or more judgments on each sample, the mean rating of each brand is computed. Coffees with ratings statistically significant at the 5% level below the grand mean rating for the six highest rating brands or the upper 50% of all those tested are considered not acceptable for procurement. It is interesting that, although the test was conducted at five different military posts each year, certain definite trends indicate the consistency and validity of the test plan. For instance, regular roasted and ground coffee, which was used as a control but the rating of which was not included in the averages, rated the same each year with only one exception. In 1950, all seven brands of instant coffee rated *below* the fresh coffee beverage in acceptability although some were insignificantly inferior. In 1952, nine out of eleven brands tested rated *above* the fresh coffee; in 1953, all eight samples—in 1954, all nine samples—in 1955 and 1956, all thirteen samples, tested rated higher than fresh coffee and in 1957, preliminary results indicate that all 15 samples will rate higher than the fresh coffee.

It is obvious that, even without military interest, improvements in quality would have progressed at a rapid pace. Nevertheless, it is felt that this annual soldier-consumer test has played an integral part in stimulating friendly competition among the producers as well as insuring high quality instant coffee for the operational rations of the Armed Forces.

Increasing use of instant. I have been asked many times what percentage of the coffee market does instant coffee represent. Instant coffee consumption has been increasing steadily since 1946 when it represented only 6% of the total coffee consumed in this country. From 1946 until 1951, its share of the market rose gradually to about 13%. Since 1951, aggressive advertising, and promotion of national brands coupled with the growing demand for convenience items as well as a definite improvement in the quality of instant coffees have increased its share of the coffee market to slightly over 35%. Remember that mile-wide pool of coffee I described earlier? One-third of that depth is instant coffee! My own personal estimate is that instant coffee will capture at least 50% of the market by 1960. It has already taken over 50% of the Eastern seaboard market.

Now what is the point to all of this discussion on instant coffee? How can we sum it up? Instant coffee is big business, and it's getting bigger. It has everything in its favor for proper development: a foundation in good economics, a uniform flavor, long shelf life, excellent utility. Our results indicate, quite conclusively, that cup after cup it is equal to or better in flavor than freshly brewed coffee of good quality. Food Technologists should be proud of their accomplishments in this comparatively new branch of the industry. The industry has finally come of age, and it will be a long time before it reaches retirement.

N. CALIFORNIA

DeEds Sounds a Tocsin on Toxins. Dr. Floyd DeEds, the Pharmacology Section Head at WURDD (WRRL) Albany, California, and an outstanding authority on the toxicology of foods, dropped enough block busters to completely shatter the complacency of the 70 odd IFT members who heard his speech. Most of us were aware, prior to the talk, that the addition of substances not naturally occurring in food, is often necessary and that such substances must be carefully evaluated as potential health hazards. Dr. DeEds, in the main, concerned himself with toxic substances which are *naturally* present in foods. He quoted A. C. Frazer in saying that "Synthetic chemicals are no more likely to be toxic than natural substances—indeed many of the most potent poisons known are of natural origin. Substances that have been consumed as food for centuries are not necessarily harmless, since millions of people have died from unknown causes over the same period." After naming a number of "natural" toxins and discussing their effect on life processes, Dr. DeEds went into some of the complexities of toxicological evaluations. Ap-

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parently almost every toxin is a special case all by itself. In his words "A foolproof methodology of evaluating the chronic toxicity of a compound does not exist. The manifestations of chronic toxicity may be so diverse, and the mechanisms of their production so varied that no single experimental design can be set up and accompanied by a statement that this is the procedure for evaluating the health hazard of compound X."

Dr. DeEds pointed to nitrogen trichloride as an example of the foregoing. Following a thorough toxicological evaluation it was used by the milling industry for about 20 years as an ageing and bleaching agent until illness in dogs was traced to its reaction product with methionine, an amino acid.

Dr. DeEds left this reporter with the impression which so often follows a successful talk: that all which should be known—isn't, and there is a lot of enjoyable work ahead of us in filling the gap.

H. W. ADAMS

Masters and Doctors in Food Technology and Related Subjects—1957

The second section of the 1957 roster of graduates in food technology is presented herewith. The first section appeared in the August issue of Food Technology. Once again a diversity of problems and a considerable range of approaches characterize the research that has won degrees for the 1957 crop of graduates.

Michigan State University at East Lansing

Name	*Degree*	*Thesis Title*
Bonner, Milford D.	Ph.D.	Microbiological Spoilage of Cottage Cheese
Broitman, Selwyn Arthur	Ph.D.	Methods for Estimating the Psychrophilic Populations and Keeping Quality of Milk
Herald, Carl T.	Ph.D.	Fractionation and Characterization of Soluble and Insoluble Proteins of the Milk Fat Globule Membrane
Humphreys, Thomas W.	Ph.D.	Studies on the Nutritional Requirements of Bacillus Coagulans
Newcomer, J. Leon	Ph.D.	Relation Between the Depth Distribution of Ionization and the Lethal Effects on Bacteria
Rodriguez-Arias, Jorge	Ph.D.	Desorption Isotherms and Drying Rates of Shelled Corn in the Temperature Range of 40° to 140° F.
Weber, F. J.	Ph.D.	The Identification and Physicological Activities of Psychrophilic Microorganisms in Milk
Zoha, Syed Mohammed Shansuz	Ph.D.	Studies on the Sporulation and Germination of Putrefactive Anaerobe 3679
Angelini, Pio	M.S.	A Study of Carbon Dioxide Absorption Equipment for Controlled Atmosphere Fruit Storage
Bean, Maura Lyons	M.S.	The Effect of Various Sugars and Syrups on the Viscosity and Gel Strength of a Five Per Cent Cornstarch Paste
Bünemann, Gerhard	M.S.	Anatomical Changes in the Fruit of the Rubel Blueberry During Storage in Controlled Atmosphere
Chace, William G., Jr.	M.S.	A Vinyl Plastic Tent for the Controlled Atmosphere Storage of Apples
Gillette, Allan K.	M.S.	Quantity Determination of Bulk Milk
Jokay, Louis	M.S.	The Effect of Variance in Pipe Line Installations on the Acid Degree of Fat in Milk
Keppler, Richard A.	M.S.	Time Study of Ice Cream Plants by Work Sampling Technique
Mayne, Eric	M.S.	The Principles of Fruit and Vegetable Pre-packaging and Their Application in Northern Ireland
Meiske, Donna Poland	M.S.	The Effect of Kind and Concentration of Sugar on Glutin Formation and Character
Robach, Donald Lewis	M.S.	A Comparative Study of the Morphological Characteristics of Nitrate Reducing and Non-Reducing Strains of Lactobacillus Plantarum
Robbins, Edward K.	M.S.	The Identity and Heat Tolerance of Microorganisms Causing Spoilage of Pasteurized Sweet Pickles
Sabath, Sheldon R.	M.S.	A Study of the Effects of Fungicides and Harvest Maturity of the Quality of Fresh and Processed Montmorency Cherries
Wales, Charles S.	M.S.	Some Factors Which Influence the Biacetyl Content of Cottage Cheese
Wang, Jaw Kai	M.S.	Drying Pea Beans Intermittently at 100° F.

The Ohio State University at Columbus

Badami, M.	M.S.	The Effect of Supercentrifugation on the Components of the Milk Lipase System
Betscher, J.	M.S.	The Effect of Valve Design on Homogenization Efficiency
Cole, Leslie	Ph.D.	A Separation of Natural Waxes by Chromatographic Procedures
Crawford, T. M.	Ph.D.	The Development and Application of Specific Gravity Techniques for the Evaluation of Maturity in Fresh, Frozen and Canned Sweet Corn
Davis, D. Robert	M.S.	Objective Measurement of Consistency in Cream Style Corn

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Name	*Degree*	*Thesis Title*
Dehority, Burk A.	Ph.D.	Isolation, Identification and Studies on the Metabolism of Rumen Microorganism Growth Factors in Natural Materials
Derks, Miriam A.	Ph.D.	A Study of Lipogenesis in Mammary Tissue
Hamilton, William R.	M.S.	The Effect of Size Grading and Specific Gravity Separation upon Baking, Freezing, and Reheating of Frozen Baked Potatoes
Hunt, Walter G.	Ph.D.	A Study of the Proteolytic Factors of Rumen Microorganisms
Johnson, Robert	Ph.D.	Factors Affecting the Yield, Fat Content, and Color of Potato Chips
Poshyachinda, Kaisri	M.S.	Effects of Phosphate Compounds on the Water-Holding Capacity of Meat
Rao, P. S.	M.S.	Ripening Patterns of Paraffined and Film Wrapped Cheddar Cheese
Read, Merrill Stafford	Ph.D.	The Effect of Hormone on the Intermediary Metabolism of Mammary Glands
Reisfeld, Ralph A.	Ph.D.	A Study of the Calcium-Binding Properties of Whole Casein, Alpha-Casein, and Beta-Casein
Vanecko, Steve	Ph.D.	Oxidative Phosphorylation in Cotyledons Pisium Sativum, var. Alaska
Vell, Donald C.	M.S.	Milkfat Control in Dairy Plants in Four Ohio Markets
Wu, Ming-an	Ph.D.	The Flavinoids of the Tomato (Lycopersicum Esculentum)

NICHOLAS APPERT AWARD
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The Nicholas Appert Medal and an honorarium of $1000, is awarded annually to a person for "pre-eminence in and contributions to the field of Food Technology."

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Nominations must reach the Chairman of the Jury on or before December 15, 1957.

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Literature

BOOKS

CHEMISTRY OF NATURAL FOOD FLAVORS—A SYMPOSIUM. Ed. by J. H. Mitchell, Jr., N. J. Leinen, E. M. Mrak, and S. D. Bailey. Advisory Board on Quartermaster Research and Development Committee on Foods. Department of the Army Quartermaster Research and Engineering Command. Washington, D. C., 1957.

CHEMISTRY OF NATURAL FOOD FLAVORS is a new appearance in the Quartermaster series entitled Surveys of Progress on Military Subsistence Problems. The ninth of the "round-up" conference proceedings published in the food stability series, this 200-page document defines in considerable degree the position of flavor research today. The program was organized for the Committee on Foods by Dr. Mitchell (formerly of the Quartermaster Food and Container Institute for the Armed Forces and now head of the Food Technology Department, Clemson College) with the assistance of Drs. Mrak and Bailey. Mr. Norbert J. Leinen, formerly of the Quartermaster Food and Container Institute and now with FOOD PROCESSING, accomplished the technical editing.

Contributions to the Symposium begin with interesting background material on "the emerging science of flavor" by Colonel J. D. Peterman, Dr. D. K. Tressler and Dr. E. M. Mrak. Techniques and methods of flavor research cover the mechanisms of taste and of odor perception (Dr. L. M. Beidler), measuring the attributes of flavor (Drs. F. J. Pilgrim and H. G. Schutz) and gas chromatography and mass spectrometry (Dr. W. H. Stahl).

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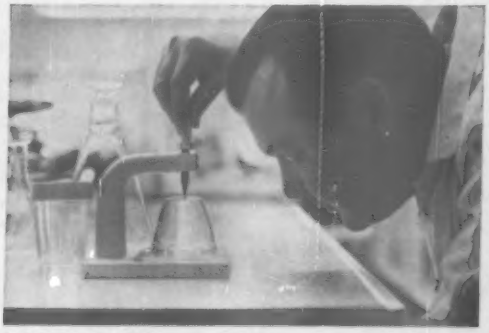

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The chemistry and technology of specific flavors are discussed by Dr. T. Hasselstrom (cabbage flavor) Dr. W. L. Stanly (citrus flavor), Dr. R. E. Eskew (deciduous fruit), Drs. K. P. Dimick and J. Corse (strawberry flavor), Dr. F. V. Kosikowski (cheese flavor), Dr. L. Wiseblatt (bread flavor), Dr. J. F. Caul (beef flavor), Dr. D. W. Peterson (chicken flavor), and Dr. E. E. Lockhart (coffee flavor). Viewed collectively, here are the flavors of a complete menu.

Flavor propagation through enzymatic action was presented by Dr. E. J. Hewitt, who has been a leading figure, along with D. A. M. Mackay, K. S. Konigsbacher, Torsten Hasselstrom, and others, in exploring the complex chemical changes brought about by the catalytic effect of enzymes on flavor precursors.

As Dr. A. J. Haagen-Smit states in an entertaining and competent summing up, "Each paper in this symposium is, in effect, a summary of an important field of present day flavor research." Although a bit extraneous in view of the serious and able job done by the summarizer, Dr. Haagan-Smit's amusing reference to one of his credentials as a flavor expert is well worth passing along: "I am engaged at present in a super flavor problem," he declared, "the flavor of the City of Los Angeles." Reference is made to his participation in solving the smog problem. Incidentally, Dr. Haagen-Smit's brief account of the photochemical events in smog formation and their analogues in off-flavor occurrences contains some striking comments.

Limited distribution of this document is being made by the Quartermaster Food and Container Institute for the Armed Forces, 1819 West Pershing Road, Chicago 9, Illinois.

MARTIN S. PETERSON
Chicago, Illinois

ANALYTICAL MICROSCOPY, ITS AIMS AND METHODS IN RELATION TO FOODS, WATER, SPICES AND DRUGS. 2nd ed., T. E. Wallis, Little, Brown and Company, Boston, Mass., 215 pp.

Miscroscopy is a science in which it is difficult to record observations so that fellow investigators can make maximum use of the published information. Also, in many areas of applied microscopy investigators have failed to publish their findings. Published information in the field is most welcome by individuals charged with the responsibility of using the microscope to help solve problems.

Frequently an understanding of structure and organization as revealed by the microscope helps solve our problems. The second edition of *Analytical Microscopy* describes methods of preparing materials for microscopical study which facilitates the observation of morphological structure. The book contains an abundance of cataloged information of a fundamental nature showing the morphological traits that characterize a wide variety of materials of plant, animal, and mineral origin.

There are 14 chapters: Introduction; Simple Methods of Preliminary Treatment; Surface Preparations and Sections; Sedimentation and Centrifugation; Kneading—Starch and Bran; Elutriation and the Use of Solvents; Solvents and Clearing Reagents; Further Preliminary Treatment; Chemomicroscopy; Micromorphology; Sublimation, Precipitation and Staining; Measurement and Drawing; Numerical Values; and Quantitative Microscopical Analysis.

There are many references to original articles and books and the information in the book is well indexed, thus making it very useful for research as well as for analytical investigations. However, one should appreciate that in this field a book will not permit one unfamiliar with the science to become an "expert" by merely reading published information. Microscopy is a field where competence is gained only after years of diligent study and experience.

This book should be useful to the student of microscopy as well as the experienced investigator.

CARL H. KOONZ
Chicago, Illinois

ABSTRACTS

—Compiled by H. A. Campbell

ANALYTICAL METHODS

Vapor phase chromatography and the telegrapher's equation.

GOLAY, M. J. E. (The Perkin-Elmer Corp., Norwalk, Conn.). *Anal. Chem. 29*, 928-32 (1957).

Mathematical theory of kinetics of gas chromatography is developed by comparison of fractionating columns to an electrical transmission line. Several conclusions, such as existence of an optimum carrier gas flow rate for max. band sepn., are derived from the simple theory established.

Determination of 2,6-di-tert-butyl-p-cresol in edible fats by ultra-violet spectrophotometry.

PHILLIPS, M. A., AND HINKEL, R. D. (Koppers Co., Inc., Verona, Pa.). *J. Agr. Food Chem. 5*, 379-84 (1957).

The method determines 20-200 p.p.m. of 2,6-di-*tert*-butyl-*p*-cresol (1) in lards in the presence of other preservatives, including BHA, NDGA, propyl gallate, citric acid, monoisopropyl citrate and phosphoric acid. The lard sample is dissolved in cyclohexane and percolated through a chromatographic column packed with 100-mesh silicic acid. By washing the column with successive portions of cyclohexane, 1 is selectively removed and recovered in the filtrates. The filtrates are then analyzed by u.v. spectrophotometry and the amt. of 1 calcd. from absorbance measurements made at 284 mμ.

BIOLOGICAL SCIENCES

BIOCHEMISTRY

Role of amino acids in the browning of orange juice.

JOSLYN, M. A. (Univ. of California, Berkeley). *Food Research 22*, 1-12 (1957).

New data on the oxidative browning of ascorbic acid-amino acid-sugar system is presented which indicates that ascorbic acid is the most reactive component and that glucose and fructose inhibit its browning. Amino acids in the initial stages inhibit browning, but in later stages increase it. The concn. of ascorbic acid initially present has a marked effect on rate and extent of browning of ascorbic acid solns. Lysine and glutamic acids are most reactive amino compds.

Influence of addition of certain amino acids and vitamin B_{12} to proteins in enriched milled wheat flour on growth, protein efficiency, and liver fat deposition.

SURE, B. (Univ. of Arkansas, Fayetteville, Ark.). *J. Agr. Food Chem. 5*, 373-5 (1957).

The proteins in milled wheat flour were fed to albino rats at an 8% level for 10 weeks. The optimum gains in wt. and protein efficiency were secured by supplementation with 0.4% L-lysine, 0.2% DL-threonine, 0.4% DL-methionine, and vitamin B_{12}.

Enzyme catalysis and enzyme specificity-combination of amino acids at the active site of phosphoglucomutase.

KOSHLAND, D. E., AND ERWIN, M. J. (Brookhaven Natl. Lab., Upton, L.I., N.Y.). *J. Am. Chem. Soc. 79*, 2657-8 (1957).

Data indicate that the amino acid sequence of the active site for at least 6 amino acids is the same for an enzyme which specifically hydrolyzes peptide bonds and an enzyme that specifically transfers phosphate between carbohydrate mols.

Specific enzymic method for the estimation of L-tryptophan.

FRANK, L. H., AND DEMOSS, R. D. (Johns Hopkins Univ., Baltimore, Md.). *Arch. Biochem. and Biophys. 67*, 387-97 (1957).

A procedure is described for the enzymic assay of L-tryptophan utilizing the enzyme tryptophanase. Tryptophan is converted to indole; colorimetric estn. of the indole produced from an unknown sample allows the estn. of its tryptophan content. Under the conditions described, a series of indole derivs. casamino acids, and D-tryptophan do not interfere either singly or in combination.

Determination of phenol oxidase using a manometric method by Streptomyces antibioticus.

SEVCIK, V. (Czechoslovak Acad. of Sci., Prague). *Nature 179*, 966-7 (1957).

In a study of phenol oxidases in *Streptomyces antibioticus* No. 105/5 producing actinomycin, a manometric method was used. Sodium cholate, a surface-active agent, was used, permitting the specific substrate to enter intact cells. In addn., this also considerably inhibited the high endogenous respiration. Catechol, hydroquinone, *p*-phenylenediamine, *p*-cresol and tyrosine served as substrates in a concn. of 5 mg./ml. Oxygen consumption was measured at 30° C. Good results were also obtained with other surface-active substances; for example, "Syntergit" and "Likorol VEL" at the same concn. as cholate and "Tween 80" (0.1 ml. of 15% aq. soln. per 3 ml. of fluid).

Biological availability of isoleucine.

DESHPANDE, P. D., HARPER, A. E., COLLINS, M., AND ELVEHJEM, C. A. (Univ. of Wisconsin, Madison). *Arch. Biochem. and Biophys. 67*, 341-9 (1957).

Biological availability of isoleucine in eight different proteins was detd. using a blood meal diet low in isoleucine. Iso-

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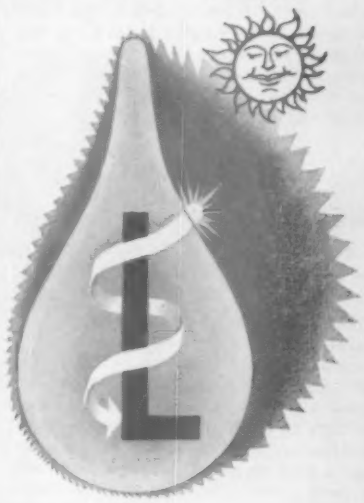

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leucine in zein was available to the extent of 30%; in casein and gelatin, around 60-70%; and in fibrin, beef, egg albumin, and Drackett soybean protein, over 90% of the isoleucine was available to the rat. In the case of zein, there was an increase of from 30 to 60% in the availability of isoleucine, when the acid-hydrolyzed zein was fed. No such effect was observed with the hydrolyzates of casein and fibrin.

NUTRITION

Amino acid supplementation of oats.

BENTON, D. A., AND TANG, J. N. (Oklahoma A. and M. Coll., Stillwater). *Federation Proc. 16*, 381 (1957).

Differences were observed in the wt. gains of weanling rats when different varieties of oats were fed as the source of protein. A supplement of lysine increased the wt. gained by rats fed oats of high nutritive value. A supplement of methionine alone reduced the wt. gain and a supplement of threonine alone was without effect. Supplements of lysine and methionine or lysine and threonine caused no more wt. gain than lysine alone.

Amino acid imbalance in low protein diets.

DESHPANDE, P. D., AND ELVEHJEM, C. A. (Univ. of Wisconsin, Madison). *Federation Proc. 16*, 384 (1957).

In the present investigation diets contg. only 6% of fibrin were used. When young rats were fed this diet, the addn. of 0.4% DL-methionine caused growth retardation but fat did not accumulate in the liver. Supplementation with histidine, phenylalanine, leucine, isoleucine and valine overcame the adverse effect of methionine and stimulated growth but at the same time fatty infiltration of the liver occurred. When any one of the above amino acids was omitted growth was inferior to that obtained when all 6 amino acids were included. The results suggest that although addn. of methionine to the basal diet created an imbalance which was much more complex in nature than that obtained in previous studies with casein diets, methionine was limiting for maximum growth when other amino acids were included.

Comparison of amino acid mixtures and egg protein as sources of dietary nitrogen.

NASSET, E. S. (Univ. of Rochester Sch. of Medicine and Dentistry, N.Y.), *J. Nutrition 61*, 555-69 (1957).

An amino acid mixt. based on the mean min. requirements of 9 essential amino acids, detd. individually in previous expts., is significantly inferior to either egg protein or an amino acid mixt. which simulates egg protein. The essential amino acid requirements for the maintenance of N equil. in the rat and man are compared.

Role of the digestive tract in the utilization of protein and amino acids.

NASSET, E. S. (Univ. of Rochester, Sch. of Medicine and Dentistry, N.Y.). *J. Am. Med. Assoc. 164*, 172-7 (1957).

The ingestion of protein stimulates the digestive tract to secrete endogenous protein, which becomes mixed with the food protein to provide an amino acid mixt. for absorption that remains relatively const. in compn. Proteins of widely different amino acid compn. and even nonprotein foods give rise to amino-acid mixts. in the small intestine that are similar. The result of this mixing of amino acids in the lumen of the intestine may be to regulate rather closely the relative concns. of the amino acids available for absorption.

Supplementation of dietary proteins with amino acids.

FOOD AND NUTRITION BOARD, NATL. ACAD. OF SCIENCES—NATL. RESEARCH COUNCIL. *Public Health Repts. 72*, 469-70 (1957).

At least eight amino acids must be supplied daily by the protein in the diet in proportions and amounts to meet the requirements of metabolism. Any dietary protein which is relatively deficient in one or more of these essential amino acids has a reduced nutritive efficiency. Emphasis is placed upon the development of an adequate pattern of essential amino acids in the diet as well as upon the maintenance of an adequate protein intake. The imbalance of essential amino acids found in some dietary proteins cannot always be corrected by adding a single amino acid, the imbalance being the result of a deviation in several of the essential amino acids from an "ideal pattern" needed by the body. Multiple supplementation is generally required. This type of supplementation is at present best achieved by mixed diets where one food protein supplements another.

Effect of protein level in the ration on gossypol tolerance in growing-fattening pigs.

HALE, F., AND LYMAN, C. M. (Texas A. & M. College System, College Sta.). *J. Animal Sci. 61*, 364-9 (1957).

Restriction of the free gossypol content of the ration to 0.01% or less provided a safe level for feeding cottonseed oil meal to growing-fattening pigs. Such rations may be self-fed in self-feeders with good results. Although levels of free gossypol above 0.01% resulted in toxicity symptoms and death of some of the pigs in each group receiving 15% protein ration, none of the pigs receiving the 30% protein ration showed any symptoms of toxicity whatsoever.

Protein supply for human nutrition.

KING, C. G. (Nutrition Foundation, Inc., N.Y.). *J. Agr. Food Chem., 5*, 340-2 (1957).

Review of the protein malnutrition problem throughout the world.

Dietary protein and serum cholesterol in rats.

MOYER, A. W., KRITCHEVSKY, D., LOGAN, J. B., AND COX, H. R. (Am. Cyanamid Co., Lederle Labs., Pearl River, N.Y.). *Proc. Soc. Exptl. Biol., 92*, 736-7; *Intern. Abstr. Biol. Sci. 6*, No. 428 (1957).

When protein was added to a diet contg. cholesterol and cholic acid which usually increased the blood cholesterol, a progressive drop in serum cholesterol values occurred. Both casein and purified soya-bean protein had this effect.

Dietary fat and cholesterol metabolism. I. Comparative effects of coconut and cottonseed oils at three levels of intake.

OKEY, R., AND LYMAN, M. M. (Univ. of California, Berkeley). *J. Nutrition, 61*, 523-33 (1957).

Data are reported on lipid and cholesterol in liver and serum of rats fed, resp. 5, 10, and 15% of coconut oil and of cottonseed oil slightly hardened by the addn. of some of the completely hydrogenated fat, each with and without 1% cholesterol. When cholesterol was fed the linoleic acid-rich cottonseed oil led to more storage of liver cholesterol ester than did coconut oil. The data are discussed in relation to the specific effect of linoleic acid on mobility of cholesterol, and its preferential use in the formation and storage of cholesterol esters.

Calories and cholesterol.

KEYS, A. *Geriatrics, 12*, 301-10 (1957).

The great differences in frequency of coronary heart disease in different countries appear to be closely correlated with the av. serum cholesterol concns. in samples of the populations, which in turn appears to be closely correlated with the proportion of fats in the habitual diet. Unsaturated and linoleic fats tend to affect the serum cholesterol level in the opposite direction to the satd. fats.

Value of gelatin as a nutritional supplement.

BRIN, M., OSER, B. L., AND OSER, M. (Food Research Labs., Inc., Long Island City, N.Y.). *Federation Proc., 16*, 158 (1957).

The addn. of gelatin a) to basal diets contg. protein of which only 6.6% is derived from animal sources but which vary in total protein level, viz., 11, 15, and 20% of the diet, or b) to basal diets contg. 11% protein of which increasing proportions, viz., 6.6, 25.5 and 60.7%, are

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derived from animal sources, resulted generally in markedly increased growth of weanling rats. Efficiency of food utilization (EFU) and nitrogen efficiency (NE) were enhanced under these conditions by supplementation with gelatin. Results indicate the dietary protein conditions under which gelatin can make a positive contribution to the diet.

The addition of small amounts of defatted fish flour to milled wheat flour, corn meal and rice. Influence on growth and protein efficiency.

SURE, B. (Univ. of Arkansas, Fayetteville). *J. Nutrition, 61,* 547-53 (1957).

A study was made of the influence of addns. of small amts. of defatted fish flour to the proteins in milled wheat flour, white corn meal, and polished rice. The enormous gains in body wt. and protein efficiency obtained were far superior to those secured in the past with dried non-fat milk solids, dried buttermilk, defatted soybean flour, brewers' yeast, cultured food yeasts, and peanut meal. Results may prove of material assistance in combating protein deficiency diseases such as kwashiorkor.

The vitality of the vascular system.

BORTZ, E. L. *Geriatrics, 12,* 275-83 (1957).

The concn. of lipids in the plasma and the time it remains high favor deposits in walls of blood vessels. Chylomicron counts suggest slowing of lipid clearance following fat meals in older individuals. Heparin accelerates clearance of plasma lipids. Exercise, a neglected factor, may speed metabolism, thus reducing lipid concn.

Observations on dietary sodium chloride.

BALL, C. O. T., AND MENEELY, G. R. (Vanderbilt Univ. Sch. of Med., Nashville, Tenn.). *J. Am. Dietet. Assoc. 33,* 366-70 (1957).

Five hundred and forty-six male and 21 female Sprague-Dawley rats were fed demineralized H_2O and purified diets contg. from 0.15 to 21% NaCl. When first placed on exptl. diets, marked polydipsia and polyuria occurred among the rats eating increased NaCl. After 3 days, these rats appeared to be severely dehydrated. Two weeks later they all appeared to be healthy and were gaining wt. regularly, although growth was adversely influenced by the amt. of added NaCl. Edema at the 3rd or 4th month was the earliest untoward effect occurring in 15% of the rats eating 7% or more of NaCl. "Increased NaCl correlated positively with mean H_2O consumption, blood pressure, radio-Na space, incidence of electrocardiographic abnormalities, serum cholesterol, heart wt., and kidney wt. and correlated negatively with mean stem length, wt., and longevity.

Cancer and food additives.

FOOD AND NUTRITION BOARD, NATL. ACAD. OF SCIENCES—NATL. RESEARCH COUNCIL. *Public Health Repts. 72,* 449-50 (1957).

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A statement given by the Food and Nutrition Board, Natl. Research Council clarifying for the public the present state of knowledge about the relation between food additives and occurrence of cancer in man.

Is toxicology enough for a food protection program?

MICKELSEN, O. (U. S. Dept. of Health, Education, and Welfare, Bethesda, Md.). *J. Am. Dietet. Assoc. 33*, 341-6 (1957).

The author discusses the fact that the old method of studying a toxic agent in its pure form may be invalid. A no. of substances that are or have been proposed for use in the food industry would elude a detection program based solely on this method. Some substances are relatively nontoxic, but when used in the processing of food, they react to produce marked chem. or nutritional changes.

Nutritional status and dietary habits of older people.

BATCHELDER, E. L. (Agr. Research Service, U.S.D.A., Washington, D.C.). *J. Am. Dietet. Assoc. 33*, 471-6 (1957).

A decrease in calories and other nutrients was a common finding in 2800 women and 250 men with advancing age. Groups averages were found to be below the recommended allowances. On the other hand, obesity and poor food selection were also common. A review of food intake and lab. findings is included.

Nutrient intake of college men.

YOUNG, C. M., EINSET, B. M., EMPEY, E. L., AND SERRAON, V. U. (Cornell Univ., Ithaca, N.Y.). *J. Am. Dietet. Assoc. 33*, 374-7 (1957).

The nutrient intakes of 229 entering Cooper Union male students and 61 representative Cornell Univ. men, based on seven-day food records, are presented, with particular reference to the fat, carbohydrate and protein distribution of the caloric intake. Calories and thiamine were the nutrients where the highest percentage of men from each school failed to meet the Recommended Dietary Allowances and also where the highest percentage were at the lower levels of intake. About 15% of all calories came from protein; 40% from fat and 45% from carbohydrates.

PHYSIOLOGY AND MEDICINE

Atherosclerosis: A hypothesis concerning the initiating steps in pathogenesis.

HARMAN, D. (Univ. of California, Berkeley). *J. Gerontol. 12*, 199-202. (1957).

A hypothesis has been developed concerning the initiating steps in atherosclerosis. These postulated steps are: 1) Oxidative-polymerization of constituents of serum lipoproteins; 2) anchoring of the oxidized materials in the arterial wall, and 3) an inflammatory reaction induced in the arterial wall by these condensed products. With increasing age the contribution of the first two processes increases while that of the latter decreases. This hypothesis is suggestive of means whereby the rate of progression of atherosclerosis may be inhibited.

FOOD AND FOOD TECHNOLOGY

BAKING AND BAKERY PRODUCTS

Factors affecting color stability of stored sugar cookies.

GRIFFITH, T., JOHNSON, J. A., AND NORTHAM, J. I. (Kansas State Coll., Manhattan). *Cereal Chem. 34*, 153-9 (1957).

The fading of the brown color is closely related to the relative humidity. At 34% relative humidity, decrease in darkness of the dextrose cookies was greatest when the cookies were stored in CO_2.

COCOA AND COCOA PRODUCTS

Develop cheaper equivalent of cocoa butter.

Candy Ind. & Confectioners J., 108, 51, March, 1957.

A new product which is claimed to be the first complete equivalent to cocoa butter has been manufd. by a British firm. It is chemically similar, cheaper than, and has similar phys. properties of cocoa butter. It is marketed as Coberine. A plant to manuf. it has been set up now.

COFFEE AND COFFEE PRODUCTS

Nutritional evaluation of coffee including niacin bioassay.

TEPLY, L. J., AND PRIER, R. F. (Wisconsin Alumni Research Foundation, Madison). *J. Agr. Food Chem. 5*, 375-7 (1957).

The presence of approx. 10 mg. of niacin in 100 g. of ordinary retail coffees, as measured microbiologically, was confirmed by rat assay. Niacin level is dependent on degree of roasting. Experimental dark roasts contained up to 43 mg. of niacin per 100 g. of coffee and equally high levels were found in some specialty coffees obtained on the open market. The niacin is readily extd. in the prepn. of beverage. Appreciable, but rather low, levels of seven B vitamins, other than niacin, were present in coffee beverage. Moderate amts. of extractable Ca and Fe and low levels of Na and F were found in roasted coffee.

FATS AND OILS

The relation between certain characteristics of fats and oils and their apparent digestibility by young pigs, young guinea pigs and pups.

LLOYD, L. E., AND CRAMPTON, E. W. (Macdonald Coll., Quebec, Canada). *J. Animal Sci. 61*, 377-82 (1957).

A highly significant inverse relationship was found to exist between the mean mol. wt. (length of chain) of the fatty acids of various fats and oils and their apparent digestibility by pigs and guinea pigs of suckling age. Approx. 30% of the total variability in the apparent digestibility of the fats and oils by these species was attributable to fatty acid chain length. The relationship between the degree of satn. of the fats and oils and their apparent digestibility by the young pigs and guinea pigs was of minor significance. A species difference with respect to ability to utilize long chain fatty acids was indicated. Apparently the dog and the human are better able to digest fats or oils contg. a large proportion of long chain fatty acids than are the pig, the guinea pig and the rat.

SIRUP

Maple sirup. X. Effect of controlled fermentation of maple sap on the color and flavor of maple sirup.

NAGHSKI, J., REED, L. L., AND WILLITS, C. O. (Eastern Regional Research Lab., Philadelphia, Pa.). *Food Research 22*, 176-81 (1957).

Evidence is presented for generic differences in the degree and type of changes in color and flavor produced on fermentation. Some species of microorganisms produce intensification of maple flavor only, while others favor the production of caramel flavor or maple with varying degrees of caramel. The caramel flavor of maple sirup is correlated with the amt. of free reducing sugars formed during microbial growth in sap, and is especially apparent in the case of yeast fermentation.

PACKAGING

Safety evaluation of food packaging materials.

IVES, M. (Am. Can Co., Barrington, Ill.). *J. Am. Dietet. Assoc. 33*, 347-51 (1957).

Screening tests to det. the suitability of new products for food packaging materials, the toxicologic properties of which are unknown, are described.

PATENTS

Spray drying foamed material.

REICH, I. M., AND JOHNSTON, W. R. Assignors to Standard Brands, Inc. U. S. 2,788,276, April 9, 1957.

A process of spray drying aq. exts. of tea and roasted coffee, the steps of dispersing a gas of the group consisting of air, CO_2 and N in an aq. ext. of a substance of the group consisting of tea and roasted coffee to produce a foam with the liquid forming the continuous phase having a density in the range from about 0.05 to 1.0 g./ml. measured at atm. pressure and then spray drying the foam.

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INDUSTRY PUBLICATIONS

Processing Frozen Fruit with l-Ascorbic Acid (Vitamin C) has just been released in a revised fourth edition by the Vitamin Div., Hoffmann-La Roche, Inc., Nutley 10, N. J. The 36-page illustrated brochure, which had been out of print for some time, gives valuable information on proved methods for protecting the natural color and flavor of more than a dozen different fruits in the freezing process. Written in nontechnical language, the booklet covers many technical points about freezing fruits, gives helpful pointers about processing procedures and covers in detail the methods of handling peaches, apples, apricots, berries, pears and many other fruits and fruit preparations. Copies are available from the company on request.

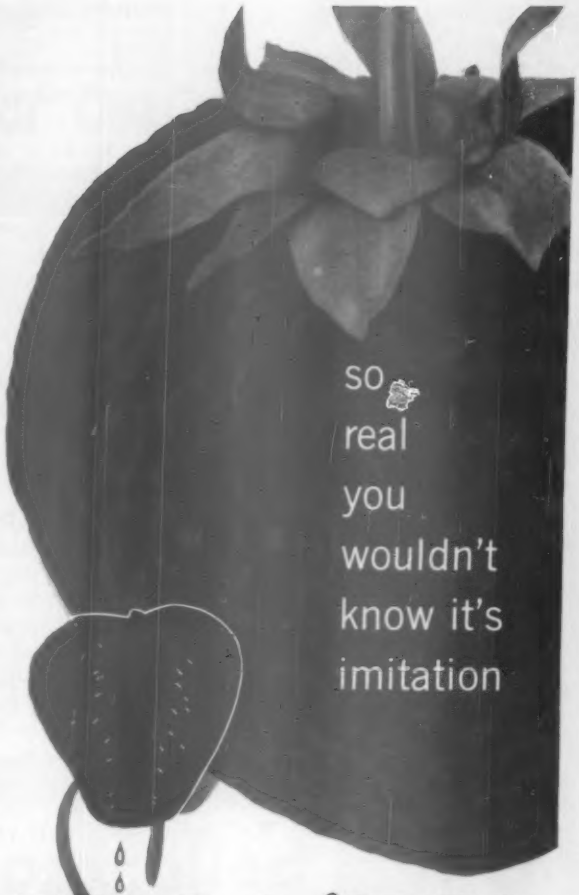
A protein precipitation process that provides an efficient and economical waste effluent treatment to reduce protein contamination is described in a new technical bulletin, **Effective, Economical Removal and Recovery of Proteins.** The bulletin explains how Indulin, a pure alkali lignin, reacts with water-soluble proteins to form a definite and stable complex that precipitates readily at reduced pH. The product is said to provide excellent protein removal from sugar beet pulp press water, thin stillage, grain syrup, vegetable-derived beverages and mash distillation residues.

Copies of the bulletin can be obtained from the Polychemicals Div., West Virginia Pulp & Paper Co., Charleston A, S. C.

Bulletin MSP-141, recently published by Hagan Chemicals & Controls, Inc., Pittsburgh 30, describes the company's newly designed line of ring balance recorders, indicators and controllers. The bulletin uses arrow-and caption treatment to explain the features of the instruments. Also of help to engineers is a table of applications showing some of the many situations in which the ring balance principle is said to give outstanding performance.

University of California scientists have completed a **study of the storage life of chilled poultry,** and have come up with a few suggestions for improving the flavor of the birds when they finally emerge from the consumer's kitchen.

Most of the poultry marketed in this country is handled as a chilled product. Because of the time-consuming processing and distribution system, it may take up to a week for the chicken to reach the consumer. Without doubt say the researchers, keeping poultry at a much lower temperature is the first requirement in poultry preservation. They recommend temperatures approaching 32° F. during processing and distribution.



FRIES & FRIES

Strawberry

FLAVOR

- for CAKE
- for ICINGS
- for CANDY
- for ICE CREAM
- for SOFT DRINKS

A basic development in flavoring! Shows excellent stability in both baked and unbaked products. This is but one example of the many outstanding flavors that are evolved and developed in our laboratories.

MANUFACTURING CHEMISTS FRIES & FRIES INC. CINCINNATI U.S.A.

NEW YORK
418 E. 91st Street

CINCINNATI
110 E. 70th Street

Tetracycline antibiotics (such as aureomycin and terramycin), already in use in some packing plants, give added protection against spoilage bacteria, report the scientists. Under commercial conditions, the antibiotics increased storage life by several days.

The report suggests that it might be wiser to postpone the cutting-up of chickens until they reach the retail market; whole birds keep much longer.

In addition to using lower temperatures and antibiotics, the group recommends several other procedures: minimize contamination during evisceration; chlorinate the slush ice used to cool poultry; wash eviscerated birds mechanically; and use better sanitation during the cutting-up operation.

The study, conducted at the University's Davis campus, was made by R. H. Vaughn, professor of food technology; G. F. Stewart, professor of poultry husbandry; and graduate students C. W. Nagel and F. M. Sawyer.

The food laboratories of Eastman Chemical Products, Inc., have reinvestigated and revised the various analytical procedures available for analyzing phenolic food-grade antioxidants. With only slight modifications, the best of these procedures are presented in a 16-page brochure, **Analysis of Phenolic Antioxidants.** Three phenolic antioxidants are covered in the text: butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT) and propyl gallate. Copies of the brochure can be obtained from the company at Kingsport, Tenn.

Industry

PRODUCTS

Oleoresin Mace. Fritzsche Bros., Inc., has announced another addition to its selection of spice oleoresins. Oleoresin Mace, now in production at the firm's Clifton plant, is described as a dark, reddish-brown, homogeneous liquid manufactured from the finest quality mace. It is said to be completely solvent-free. It contains from 50 to 60 cc. of volatile oil per 100 grams, and is said to have the clean, full flavor of the natural spice. Details and prices can be obtained from Fritzsche Bros., Inc., 76 Ninth Ave., New York 11.

Fortified Juices. The vitamin C value of canned and frozen concentrated juices can be considerably increased by addition of the anti-browning agent Fruit-Freeze, according to a report from Merck & Co., manufacturer of the product. One teaspoonful of Fruit-Freeze per 6-oz. can of concentrated juice reconstituted with three cans of water, supplies in each 4-oz. serving twice the minimum daily vitamin C requirement of adults, according to the report. The same amount furnishes three times the minimum daily vitamin C requirement of children from 1 to 12 years of age. The company says that two-thirds of the persons taking a taste test preferred the flavor of juice fortified with Fruit-Freeze to that which did not contain it.

Technical data on the product can be obtained from Merck & Co., Chemical Div., Rahway, N.J.

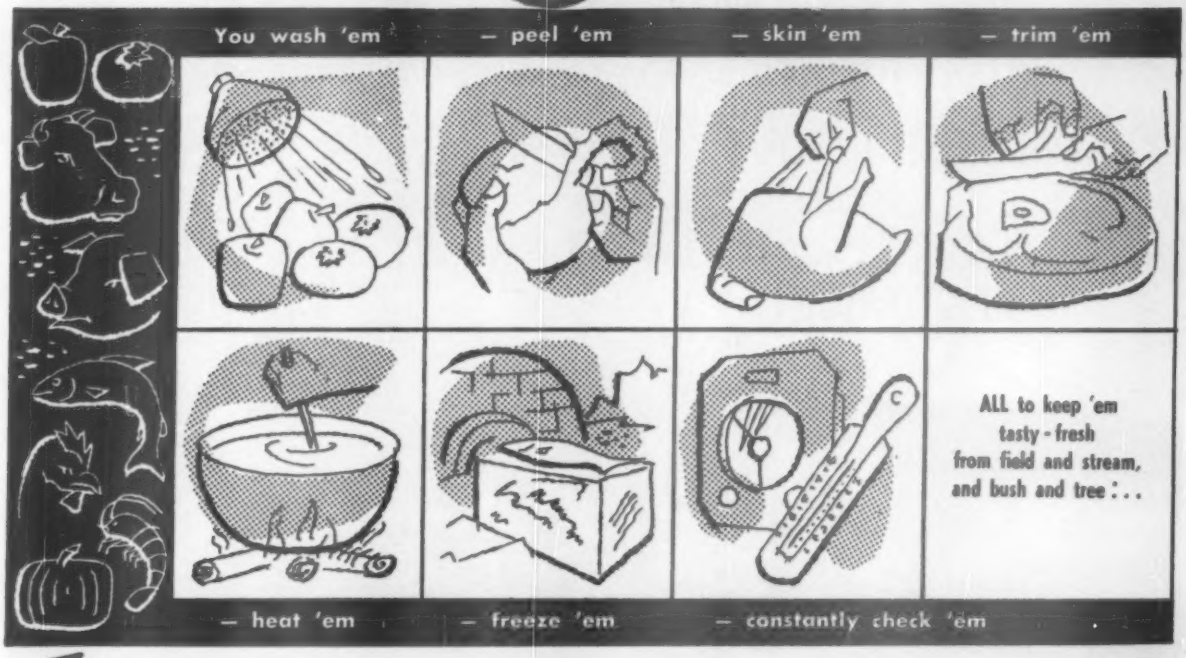
New Citrus Flavors. Dodge & Olcott laboratories recently announced development of three spray-dried citrus flavors: Dolcoseal Lemon Special ‡186, Orange Special ‡204 and Lime Special ‡205, all especially designed for use in gelatin desserts. The company says that laboratory and kitchen tests have demonstrated greatly increased shelf life of the new flavors. The flavor strength is such that 4 oz. will give a well-rounded, characteristic flavor to 100 lb. of gelatin dessert powder.

All-Purpose Cleaner. Calgon Co. has introduced a new, general-purpose commercial cleaner for manual cleaning operations in food plants, restaurants, hotels, etc. Called Pinnacle, the product is a mixture of mild alkaline cleaners, synthetic detergents and polyphosphate water conditioners. It is said to be non-irritating to the hands, and is recommended for washing dishes, glassware, stainless steel ware, tanks, sanitary pipelines, food processing equipment, and floors and walls. It is not recommended for machine use or for soaking aluminum ware. More information can be obtained from Commercial Detergents Dept., Calgon Co., Hagan Bldg., Pittsburgh 30.

Antioxidant Tablets. Takamine Laboratory is marketing isoascorbic acid in effervescent tablet form under the name Takatabs. The tablets are said to offer a convenient, accurate way to use sodium isoascorbate, since they eliminate waste, the handling of bulk containers, and weighing. Two tablets form approximately 7/8-oz. of sodium isoascorbate in solution. A technical bulletin on Takatabs, TL-400, and a handy wall chart for use in meat packing plants are available from Takamine Laboratory, Clifton, N. J.

Food Machinery Lubricant. After two years of field testing, Union Oil Co. of California is marketing a new calcium soap base nontoxic grease for use in food processing machinery. The product, called Alba grease, is of a buttery texture, extremely white in color and intermediate between NLGI Nos. 1 and 2. It is manufactured from a special calcium soap and contains non-abrasive fillers and additives. The combination is said to result in a grease that shows excellent oxidation and rust resistance even in the presence of corrosive citrus and tomato prod-

In frozen foods, too — the High note of Quality is Griffith's!


You wash 'em
— peel 'em
— skin 'em
— trim 'em
ALL to keep 'em tasty - fresh from field and stream, and bush and tree . . .
— heat 'em
— freeze 'em
— constantly check 'em

But how well-controlled is the quality of ingredients you use?

TAKE GROUND SPICES AND SEASONINGS . . .

Griffith's are Purified! Prime quality — protected by patented Sterilization Processes to rid them, for all practical purposes, of micro-organisms that may cause off-flavor or costly spoilage. *TRUE FLAVOR CONTROL!*

TAKE MEAT TENDERIZERS . . .

Griffith's Tenderizers are formulated to improve the flavor while tenderizing tough, low cost beef. Are laboratory controlled for uniform potency and stability of the active principle. *QUALITY CONTROLLED!*

TAKE PEPPEROYAL® AND SOLUBLIZED SEASONINGS

PEPPEROYAL is just one of many spices processed from Griffith's own spice extractives. Controls assure Griffith's higher standard of flavor potency and purity—always uniform, always predictable in excellence of quality. Packed airtight in batch-size bags.

Your quality control can be made easier by Griffith.

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CHICAGO 9, 1415 West 37th Street

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NEWARK

LOS ANGELES

Du Pont's non-caloric sweetener

can help you get a bigger share of this expanding market

Diet-conscious consumers spend millions ($150 million in 1956) for dietetic foods and beverages.

This couple are new customers for dietetic products. They're among the thousands of overweight adults who have discovered the new, modern low-calorie foods that are so important to their good health. And they've found that these products, sweetened with Du Pont "Cylan," have the elegant, sweet taste they like so much.

There's a large potential market for your dietetic foods and beverages because one of every four adult Americans is overweight. Sweeten your food and beverage products with Du Pont "Cylan"; It is calorie-free, stable, easy-to-use and economical.

Let us help you get your share of this ever-expanding market. We'll gladly furnish you a free experimental sample and descriptive information. Just fill in the coupon below.

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I am interested in "Cylan."
Please send me: ☐ An inspection sample ☐ A working sample
☐ Information for making dietetic _____
Name _____
Firm _____
Position _____
Address _____
City _____ Zone ____ State _____

Now! A completely new INGREDIENT FOR SOUP MIXES

SnowFlake Instant Milo Starch

8 ways better for
CANNED SOUPS AND CREAMED FOODS

1. Thickens instantly and completely.
2. Assures superlative full-bodied smoothness.
3. Completely pre-cooked under rigidly controlled conditions.
4. Disperses evenly in liquids and solutions.
5. Inherent viscosity control for easier reconstituting of dry mixes.
6. Pure, all-white, flavor-free cereal starch.
7. Fine particles of uniform size—flows freely.
8. Compatible with other food ingredients.

Ideal for use in soup mixes, SNOW FLAKE Instant Milo Starch is more flavor-free, faster-thickening. Because SNOW FLAKE requires less critical measurement of water in reconstituting dry mixes this amazing new starch gives you more leeway in formulation.

Note at left the many advantages offered by new SNOW FLAKE Starch. Write for detailed information. Ask also about technical assistance in adapting this versatile new ingredient to your requirements. Address:

CORN PRODUCTS SALES COMPANY · 17 Battery Place, New York 4, N. Y.

Corn Products also makes these well-known products for the Food Processing Industry: CERELOSE® Brand Dextrose · REX® and GLOBE® Corn Syrups · SNOW FLAKE® Instant Starch

ucts. It also is said to have extremely good mechanical stability and water resistance. The grease is especially recommended for use in food processing machinery.

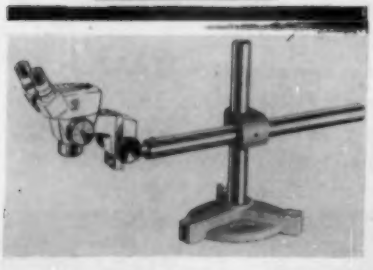
Details are available from Union Oil Co. of California, 617 W. Seventh St., Los Angeles 17.

Liquid Sugar Blend. A new liquid sugar product, "Comogenized" Flo-Sweet, recently introduced for distribution in the New York City area, combines 80% liquid sugar and 20% corn syrup in what is described as a uniform, refinery-processed blend that combines the best characteristics of both liquid sugar and corn syrup.

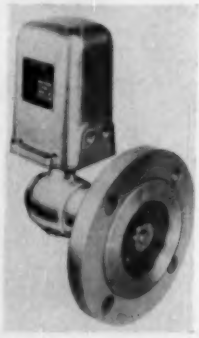
According to the manufacturer, users of sugar-corn syrup blends previously have found that mixing of the ingredients in tank trucks, even those equipped with agitators, have proved unreliable and ineffective. In addition, cold blends have generally resulted in a syrup of widely varying degrees of concentration of the two ingredients, with wide fluctuations in flavor, texture, and general quality. The new product eliminates batch blending, which many producers consider slow, expensive and liable to error, and it also does away with the need for two separate tank and pump systems.

Details are available from Refined Sugars & Syrups, Inc., Yonkers, N. Y.

EQUIPMENT



Microscope Stand. American Optical Co. has introduced a low-priced table stand for horizontal and vertical positioning of the AO Series 55 Cycloptic stereoscopic microscope. The new table stand, Model 22, features a full 360° swing around the vertical pillar, and 20-in. horizontal and 15-in. vertical adjustments. The heavy base is notched to allow attachment to the work table when a relatively permanent set-up is required. Information can be obtained from American Optical Co., Instrument Div., Buffalo 15, N. Y.



Fluid-Level Transmitter. A new differential-pressure liquid-level transmitter, introduced by the Foxboro Co., mounts directly on a tank nozzle to provide a simple method for measuring viscous or slurry-type liquids in open or closed vessels. Called the Type 13 FA d/p Cell Transmitter, it operates on the force-balance principle and maintains calibrated accuracy over a wide range of ambient conditions, according to the company.

The measuring element—a silicone-filled diaphragm capsule—is assembled in a 3-in. flange for flush-mounting on the side of a vessel. The pneumatic output of the transmitter, a 3–15 p.s.i. signal proportional to the tank level, will operate a remote indicator, recorder or controller, and no auxiliary signal amplifier is necessary. Purging systems are eliminated, since viscous liquids are measured at the tank side and not conducted through tubing. All wetted parts are Type 316 stainless steel.

Complete details, including specifications and installation diagrams, are available from the Foxboro Co., Foxboro, Mass.

Automatic Candy Making. A Skokie, Ill., candy manufacturer has applied automation to candy making, using a push-button method of continuous cooking. Developed and patented by Farley Mfg. Co., the process cooks starch slurry in five seconds by mixing it with live steam in a pressure chamber, cuts steam consumption by 85%, requires only one man to operate the equipment, produces a crystal-clear product, and doubles the shelf life of the candy through better gelatinization.

Complete automation of the process is accomplished by automatic temperature control equipment made by the Powers Regulator Co. The equipment keeps the slurry-steam mixture at the proper temperature for thorough cooking. No manual control is necessary.

The slurry ingredients are mixed in a make-up kettle, pumped into a foot-long cooking chamber where they are mixed with live steam, and delivered into a receiving kettle. A diaphragm valve and a sensitive temperature bulb mounted in the delivery pipe keep accurate control of cooking temperature. The only seam required is that for the actual cooking. None is required for evaporating surplus water from the formula, as is the case in kettle cooking.

Further information on the system can be obtained from the Powers Regulator Co., 3434 Oakton St., Skokie, Ill., of the Powers Regulator Co. of Canada, Ltd., 15 Torbarrie Rd., Downsview, Ont.

Improved Water Blancher. Important advantages in continuous processing of fragile fruits and vegetables are claimed for the new Thermascrew water blancher. Perforated flights and lifting paddles are said to overcome difficulties previously experienced in the water-blanching process. Risk of damage to fragile products is claimed to be minimized by the gentler action of the 24-in. diameter perforated flights and by maintaining optimum clearance between the trough and the flights over the full trough length.

The Amazing Versatility of creative flavors

Complete Flavors for Prepared Toppings

Supplementary Flavors for Instant Chocolate Drinks

Complete Flavors for Prepared Cake Mixes and Prepared Icings

Yes, the vast number of products that can be benefited by our complete or supplementary flavors is a surprise even to our research department where solving one problem inevitably leads to solving another.

All the way from the many different prepared mixes to instant chocolate drinks, the findings of our food technicians have shown many makers the way to more delicious, distinctive flavors that are individualized for their own product.

We would welcome any questions from Food Chemists about flavor or a visit to our laboratories.

SPECIAL PRODUCTS DIVISION
VANILLA LABORATORIES, Inc.
The House of Creative Flavors
ROCHESTER, N. Y.

At the discharge end of the blancher, perforated paddles lift the product gently onto a screen in the discharge chute. The new, curved design of these paddles is said to prevent the return of any portion of the product to the machine.

Capacity data for the blancher, designated Model TL 24K2208, are available for a wide list of products; similar data for large and smaller models to fit special requirements can be had on request from Rietz Mfg. Co., West Chester, Pa., or Santa Rosa, Calif.

Sanitary Homogenizer. A homogenizer for recombining whole milk has been developed by Central Machine Products Corp. The machine, described as practical and simple to operate, was demonstrated recently before a group of armed forces and USDA representatives. The demonstration included the complete processing of recombined whole milk using tap water, skim milk solids and fats. The ingredients were mixed, pasteurized and homogenized by the machine.

Details on the machine can be obtained from Central Machine Products Corp., 228 Pennsylvania Ave., Paterson, N. J.

Scale Remover. A new method of scale removal, for clean-up of evaporating pans used for concentrating sugar, milk and other aqueous solutions, is said to reduce labor and cost problems. A 0.5% solution of Sodium "Tetrine" liquid concentrate in a 10% caustic soda solution has been found effective for this purpose. Sodium "Tetrine" liquid concentrate is manufactured by Glyco Products Co., Empire State Bldg., New York 1, and samples and prices are available on request.

Bucket Conveyor. Food processors are offered a new bucket conveyor with special features that make for easy maintenance and cleaning. Of all-stainless-steel construction, with a food-grade neoprene belt and cover gaskets, the conveyor is said to be ideal for food industry applications. For cleaning, it is only necessary to snap off the spring clamps holding the cover doors, and then remove the belt and buckets. Models also are available with carbon steel casings and chain-mounted buckets. Heights range to 30 ft. and capacities to 5 c.f.m. Additional data are available from the Bucket Elevator Co., 360 Springfield Ave., Summit, N. J.

Koroseal Belts. Maintenance savings of 50% and a "life" that is more than twice that of conventional rubber are reported for food-handling belts made of Koroseal vinyl in operation at the Western Division of the Frito Co., Los Angeles. The firm says the new belts are in excellent condition after six months of operation. Rubber belts previously used averaged only three months' service before saturation by warm cooking oils caused them to fail.

According to the B. F. Goodrich Co., 800 Second Ave., New York 17, which produces the belts, Koroseal resists the attack of vegetable oil just as it withstands animal fats and most acids in other food handling applications. The Koroseal belts can be cleaned easily with a damp cloth and detergent, the company says, and food particles do not grind into the polished surface. The material will not support bacteria.

EXPANSION NEWS

Automatic Timing & Controls, Inc., is the new name adopted by Automatic Temperature Control Co. The firm completed early in August its move to a new, $750,000 plant at King of Prussia, Pa., 15 miles from downtown Philadelphia. Constructed with future company growth in mind, the new facilities may be expanded as much as 300%. The company produces components for industrial automation.

Architect's drawing shows new plant to be erected at Union, N. J., by the Griffith Laboratories, Inc., manufacturer of meat cures, seasonings and other basic ingredients. Situated on an 8-acre site, the building will house office, manufacturing and warehouse facilities and will be twice as large as the company's present Newark plant.

millions...

of people are seeing these messages about sugar . . . *and foods containing sugar* . . . in Life, McCall's, Reader's Digest, Sunset, and The New Yorker . . . also in 53 *big-city newspapers* reaching 35 leading U. S. markets.

read...

A very high percentage of weight-conscious people are attentively reading these informative ads, surveys show.

believe!

These people . . . consumers of your products . . . *believe* these advertisements, and *act* upon them. We know this from interview studies, and from the flood of requests for further information.

How to eat and enjoy it
...without getting fat
Is there such a thing as a "fattening" or a "reducing" food?
Should you give up any favorite food?
Why do the newer diets purposely include sugar?
Read these facts—and how sugar helps you control weight naturally.
18 CALORIES!

Sugar means sucrose (cane and beet sugar).

SUGAR INFORMATION, INC., NEW YORK 5, NEW YORK

PERSONNEL

John T. Brickner has been appointed branch manager of the Dodge & Olcott, Inc., Los Angeles office. Active in the essential oils industry for more than seven years, Mr. Brickner also has served in a related field with Vitaminerals, Inc., Glendale, Calif.

Harold J. Balhouse has been named manager of the newly formed Nuclear Div. of Alloy Steel Products Co., Linden, N. J., manufacturer of corrosion-resistant valves. He formerly was manager of special products engineering for Walworth Co. and he spent three years with Knolls Atomic Power Laboratory, where he developed prototype liquid-metal valves for the power plants of atomic submarines.

Anthony Francis has been named production manager and **Hugh Parkhurst** has been appointed purchasing agent of Gorton's of Gloucester, Inc., Gloucester, Inc., Gloucester, Mass. Mr. Francis formerly was purchasing agent and Mr. Parkhurst was assistant director of quality control and research.

William Herbst has been made supervisor of starch applications research and **Irving Martin** has been appointed senior chemist for National Starch Products, Inc. Both will work at the company's Alexander Research Laboratories in Plainfield, N. J.

Mark B. Royce and **Roger P. Conant** have been appointed as fruit and produce product managers in the eastern and southwestern districts, respectively, of the Gair Fibre Drum & Corrugated Box Div. of Continental Can Co. Both men have specialized in various methods of packaging fresh fruit and produce for the past ten years.

Royce (left) and Conant (right) of ConCanCo's fibre drum and corrugated box division.

Dr. James H. McGlumphy has been elected to the board of directors of the Research & Development Associates of the U.S. Quartermaster Corps' Food & Container Institute. Dr. McGlumphy, vice-president in charge of the Alva Flavor Div. of van Ameringen-Haebler, Inc., and a member of IFT, has worked with the Quartermaster Corps on various development projects since 1940.

Thomas L. Price has been appointed manager of manufacturing in the Buffalo (N.Y.) plant of the Buflovak Equipment Div. of Blaw-Knox Co., Pittsburgh, and the division also has named **James V. Roy, Jr.,** as senior sales engineer for its line of chemical and food processing equipment in New York City and vicinity.

Edward R. Harvey has been promoted to general manager of the Goodwin Div. of Old Judge Foods Corp., Louisville, Ky. **Daniel F. Maher,** former general manager, will remain with the firm in an advisory and consultant capacity.

William Nelson, assistant secretary of H. Kohnstamm & Co., has been appointed sales manager of the firm's western division. He will continue to serve as assistant secretary and will maintain his headquarters at the company's Chicago branch.

Dr. Kenneth W. Brighton, general manager of the new products department of American Can Co., has been appointed director of research. He will continue to supervise the new products department. Dr. Brighton succeeds **Dr. Robert W. Pilcher,** who has been named scientific coordinator. Both will make their headquarters at the firm's Research & Development Center at Barrington, Ill.

Robert C. Webster, an IFT member and former research engineer at the metal research and development laboratories of Continental Can Co. in Chicago, recently was appointed general manager of the Pressurized Food Div. of Western Filling Corp., Los Angeles.

Neal M. Draper is the new assistant to the executive vice-president of National Aniline Div., Allied Chemical & Dye Corp. Mr. Draper formerly was assistant director of sales in Allied's Solvay Process Div.

Adolph's Industrial Food Products Co., Burbank, Calif., has appointed 40 food brokers in key cities throughout the country to handle distribution of Adolph's Liquid Meat Tenderizer, recently introduced for use in frozen meat products.

Safe
Sure
Yellow
Pure

Coloring For Your Foods

Beta CAROTENE 'Roche'

WITH VITAMIN A POTENCY

HIGHLY PURIFIED CAROTENE YELLOW. Beta Carotene 'Roche' is carotene in the most highly purified form available commercially. It is free of other carotenoids, whose variable color values and lower vitamin A potencies often cause trouble in food processing. Standardize on beta carotene 'Roche' for *true carotene yellow color* without any tinge of green or red. *You'll have a better product to make your product better.*

Pure beta carotene 'Roche' crystals The Peak of Purity

SAFE AND SURE. Beta carotene is one of nature's own coloring agents. *It belongs in foods.* Even though pure beta carotene has always been considered harmless, Hoffmann-La Roche as usual took nothing for granted. During the past three years, our laboratories conducted extensive acute and chronic toxicity tests which clearly demonstrated the safety of 'Roche' beta carotene when it was administered in massive doses to test subjects over long periods.

BETA CAROTENE 'ROCHE' represents the peak of beta carotene purity and uniformity. Derived from citral obtained from lemon grass oil or other natural products, and produced by a new scientific process, the Roche product is identical chemically and biologically (as provitamin A) with beta carotene as nature makes it.

BETA CAROTENE 'ROCHE' is not a coal tar color! Beta Carotene 'Roche' does not contain coal tar! Beta Carotene 'Roche' is not in any way derived from coal tar, nor is any coal tar constituent introduced into the molecule during the Roche process of manufacture.

Since beta carotene 'Roche' gives safe yellow color with vitamin A activity (inherently included at no extra cost), it is preferred by margarine manufacturers and other food processors. We have convenient blends in sanitary tin cans or a stronger 24% semi-solid suspension (400,000 U.S.P. units of vitamin A activity per gram) in sealed, sanitary metal containers. Special forms in special packings for special purposes are available. Our technical people want to help you.

VITAMINS COME RIGHT FROM ROCHE

Vitamin Division • **HOFFMANN-LA ROCHE INC.** • NUTLEY 10, NEW JERSEY
NUtley 2-5000 • In New York: OXford 5-1400

The New Way to DISPERSE, EMULSIFY and BLEND

Particle Control with a GAULIN Homogenizer

What's the best method to disperse, emulsify or blend? It's all in Particle Control. No single piece of equipment will satisfy all requirements, so Gaulin offers three designs.

HOMOGENIZER works at high pressures, uses tremendous velocity and energy gradients to create extreme concentrated turbulence to produce more uniform, stable emulsions and dispersions.

SUB-MICRON DISPERSER handles pigments and other abrasive dispersions. S-M-D Valve uses the same hydrokinetic principles as Homogenizer to produce dispersions of ultimate fineness.

RE* COLLOID MILL is a highly advanced, two-stage design which provides continuous micrometer control for producing superior emulsions or dispersions. Operation is greatly simplified, maintenance negligible.

LABORATORY HOMOGENIZERS AND COLLOID MILLS are available on rental basis. Use them to explore the dramatic new Gaulin dimension of Particle Control.

PARTICLE CONTROL plus GTA — Gaulin Technical Assistance — is the key to new savings, better quality in your processing.

For complete data on the new RE* Colloid Mill — Ask for Bulletin C-57

Find out about all the things you can do with a Laboratory Homogenizer — Ask for Bulletin LH-55.

For technical data on Homogenizers and Sub-Micron Dispersers — Ask for Bulletins H-55 and SMD-55.

Manton-Gaulin offers complete research, laboratory and test facilities, plus 60 years' experience, to help you apply Particle Control for dispersions, emulsions and blends.

FREE! *Ask for GTA* and the Gaulin Library of Product Information . . . your best source for a low-cost solution to moving or mixing your product. Write or call today.

Gaulin TRADE MARK

MANTON Gaulin MANUFACTURING CO., INC. EVERETT, MASS.

MANTON-GAULIN MANUFACTURING COMPANY
82 Garden St., Everett 49, Mass.

AGP-10

Queen Juliana of The Netherlands (second from right) paid a visit recently to the laboratories and factories of Polak & Schwarz, flavor manufacturer, in Zaandam. Shown with Her Majesty in the flavor laboratory are C. C. Brummer and A. Schwarz (left and right), directors of the firm, and Mrs. Repelaer van Driel, a member of the royal inspection party.

Dr. Natalie K. Fitch has been named as one of the heads of a new home economics section recently established by Evans Research & Development Corp., New York City, an independent consulting laboratory. The section will offer clients information on trends in foods and household items and guidance in the application of this information to the client's own area of interest.

Dr. Frederick R. Kronenwett, a member of IFT, recently opened the American Biological Control Laboratories at 59 N. Washington Ave., Bergenfield, N. J. The laboratories will specialize in bacteriological and chemical analyses of water, food and milk, in both public health and industrial control.

Guy A. Pederzani has been named superintendent of the coating division of Nashua Corp., Nashua, N. H.

Dr. Joseph R. Leal has been appointed technical representative in the Washington office of American Cyanamid Co. He will be responsible for liaison work with the U.S. Department of Agriculture and other agencies in relation to the extensive range of Cyanamid's agricultural products and services.

William Rescorl is the new general sales manager for the Knickerbocker Mills Co., New York City. Mr. Rescorl, who has been active in the spice field for many years, formerly was sales manager of the Prepared Foods Div. of Archibald & Kendall, Inc., New York spice grinders.

Dr. L. E. Simerl, an IFT member, has been promoted to manager of research and development for the film division of Olin Mathieson Chemical Corp. He fornerly was assistant manager. Dr. Simerl succeeds **Edward Hartshorne,** who has been named general manager of the company's nuclear fuels division. Both divisions are in New Haven, Conn.

IFT member Dr. Carl Pederson (left) of the New York State Agricultural Experiment Station, Geneva, was honored recently by the National Kraut Packers Assn. for his long years of service in kraut research. Presentation of a plaque was made by Alden C. Smith of Shiocton, Wis., retiring after 10 years as association president, and the new president, Lon P. Flanigan, Jr., (right), of Geneva, N. Y.

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